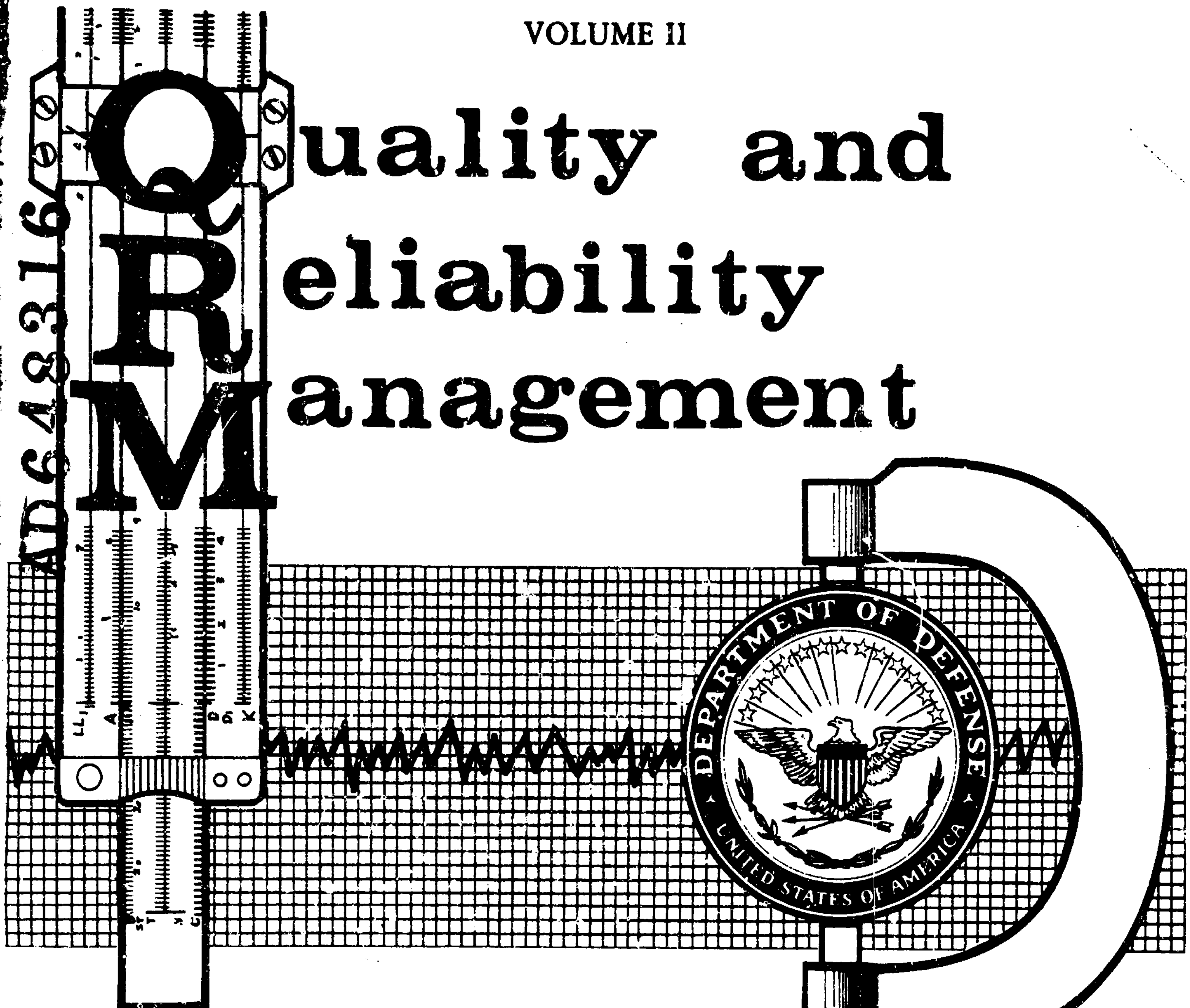
VOLUME II

Quality and Reliability Management



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DEFENSE CONFERENCE ON

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REPORT OF PANEL 1

TITLE: Quality and Reliability Management Concepts

OBJECTIVE: The purpose of the symposium is

t~~T~~o determine those objectives, concepts, policies and uniform procedures essential to effective quality and reliability management within the DoD. ( )

TOPICS DISCUSSED:

1. The Problem and Its Environment
2. Policy
3. Communication
4. Organization
5. Resources
6. Discipline
7. Integrated Engineering
8. Incentive

PARTICIPANTS

Chairman	Capt. William C. Hushing, USN, NAVSHIPSYSCOM
Panelists	Mr. Robert D. Brandon, HQS, DSA
	Mr. Roger Carroll, Jr., HQS, FSS, GSA
	Mr. John E. Condon, HQS, NASA
	Mr. James V. Harrison, HQS, AFSC
	Lt. Col. Bruce E. Hunt, HQS, USAF
	Mr. Edward E. Jones, NAVAIRSYSCOM
	Mr. Dana E. Linden, HQS, FAA
	Col. Eugene J. McGinnis, USA, Army Missile Command
	Lt. Col. Frederick D. Sparrevohn, DCASR, Los Angeles
	Mr. Wesley Thomas, Army Munitions Command
	Mr. W. A. Wildhack, NBS
Recorder	Mr. George K. Langford, NAVSEC
Deputy Recorder	Mr. Warren H. Allen, NAVSHIPSYSCOM
Monitor	Mr. E. J. Nucci, ODDR&E

THE PROBLEM AND ITS ENVIRONMENT

1. Product Environment and Performance

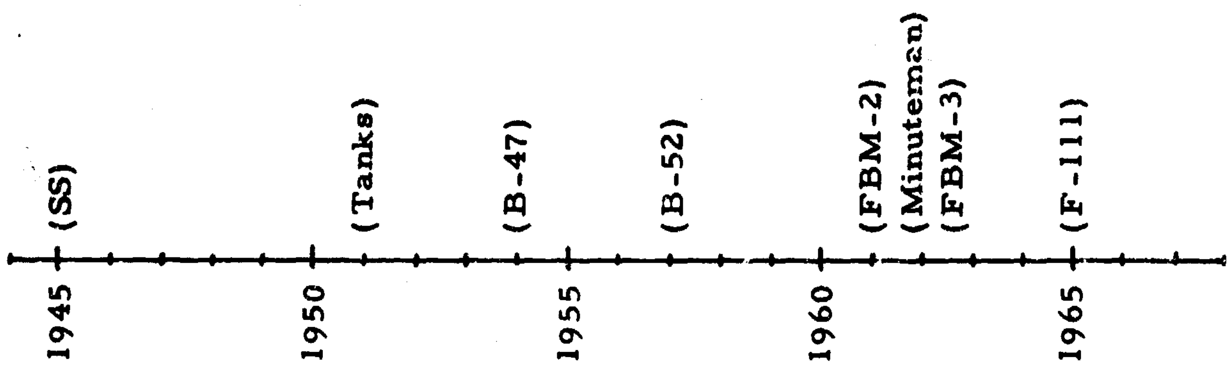
The problem connected with quality and reliability assurance is inadequately defined. The environment in which the problem exists is not well understood by most. The words by which the problem is described are imprecise and lead to misunderstanding. There is a vague feeling that quality and reliability must be improved, but there is no current measure of the costs for such improvement, thus, there can be no understanding of the trade-off between costs for quality-reliability assurance and application of the same resources to the basic product. Clearly, the problem must be much more clearly defined.

The products used by DoD and the Federal services are, in general, good. They produce the required results in the hands of the users. The record in Vietnam makes it quite clear that our airplanes, our guns, our bombs, and our supplies are adequate for the task. The record of the Strategic Air Force in maintaining its deterrent measures with B-47's, and later B-52's, over the past ten years is spectacular in terms of total number of missions accomplished, low abort and attrition rates, and high credibility. Outstanding, too, is the record of the Polaris submarine missile system which, from its initial deployment in December 1960, has provided the nation with undetected, moving, deterrent bases with all missiles up more than 98 percent of the time. This record is more outstanding when it is understood that the first stage of this missile system, i.e., the fleet ballistic submarine, goes at least four years between overhauls. The Minute Man and other missile systems, land-based, have been quite impressive in their availability and accuracy.

The nations of the world are beating a path to the door of the United States for acquisition of its weapons and items supporting the weapons, and the men who use them. This is not just because of the magnanimous attitude of this nation in providing assistance to others, but largely because there is a technical and quality superiority in these products.

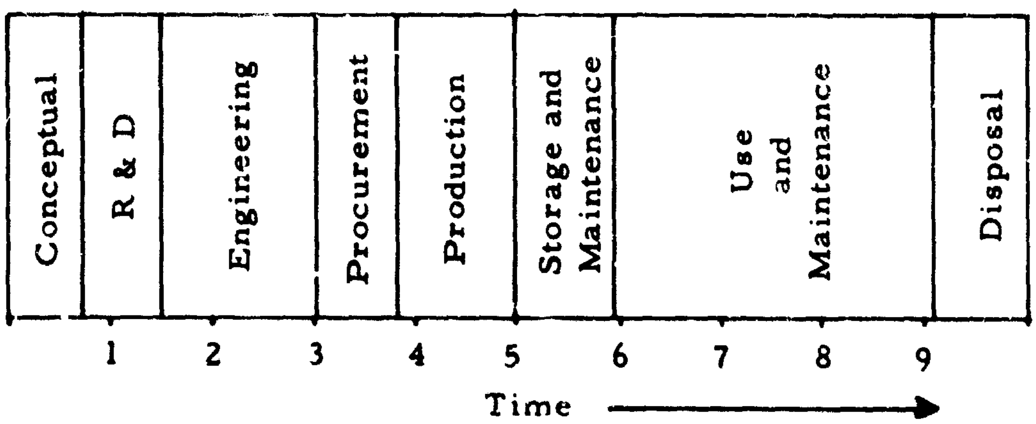
At the same time, the nation's defense services continue to use products which were built during the Korean War episode with good results. Indeed, in the case of conventional submarines, Navy-support ships, and certain other equipments, items designed, built and used in World War II are still being utilized with a high degree of success. The product age spectrum must be considered.

a. Product Age Spectrum



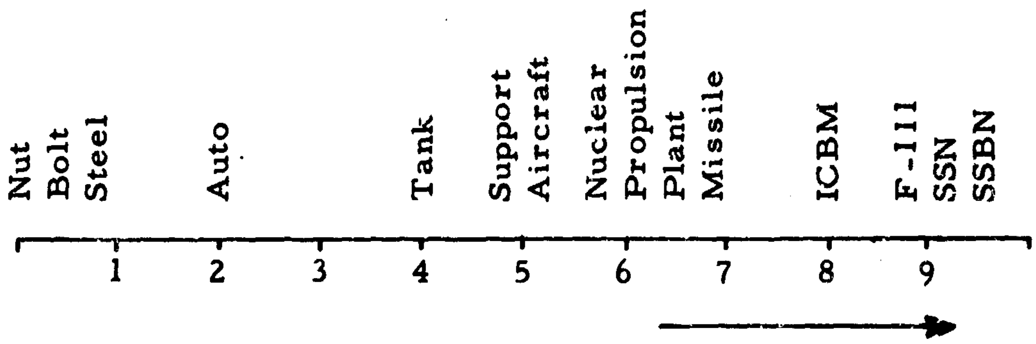
These and many other equipments must go through all parts of the product life cycle being cared for under the widest variation of climatic and geographic conditions with skilled, semi-skilled, and unskilled labor utilized in production, storage, maintenance, use and final disposal. The product life phase spectrum must be considered.

b. Product Life Phase Spectrum



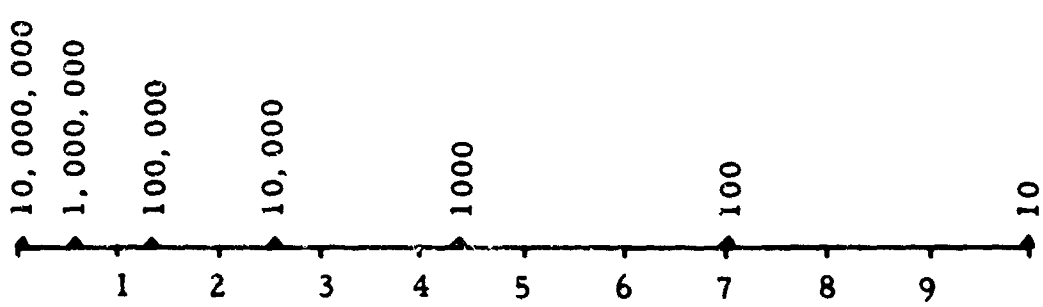
It is also clear that the products involved range from simple nuts and bolts, shoe laces, paper supplies, and the like, through increasing degrees of complexity of the higher performance bombers, fighter aircraft, missiles, detection systems and the Polaris submarines. Most of these products in use have been handled by the complete gamut of unskilled, semi-skilled and skilled personnel with success. The product complexity spectrum must be considered.

c. Product Complexity Spectrum

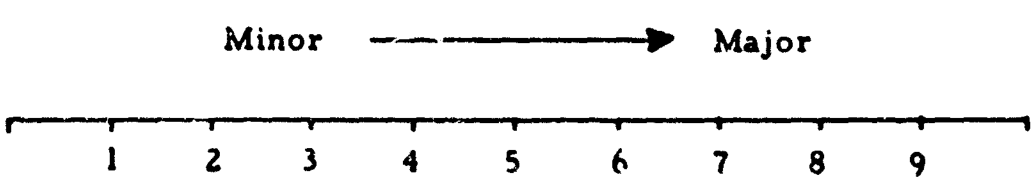


Of great importance during engineering phases of product life are the numbers to be built and the product failure consequence; these spectra are, however, closely related to product complexity and are, therefore, included in consideration of that spectrum.

d. Product Numbers (Inverse) Spectrum



e. Product Failure Consequence Spectrum



Thus, the considerations of quality, reliability and maintainability must take place in at least a tridimensional matrix configuration; first, in the widest product age spectrum; second, through the widest product life phase spectrum; and third, in the widest product complexity spectrum.

It appears unlikely that any prescribed single policy for quality, reliability or maintainability will provide a satisfactory solution unless this policy is grounded in the common sense and inherent abilities of men in the system, one which appeals to their imaginations and exhorts from them their basic best; a "You are directed" type of policy will clearly fail.

Recommendation

It is recommended that the DoD recognize the superior performance of its products and provide policy for the future which encourages all personnel elements involved in the life cycle to provide best effort.

2. Definitions Required

Inconsistent definitions of quality, quality assurance, reliability, reliability assurance and maintainability have been provided by the DoD, the Service Department Washington Headquarters, service field activities and subordinate elements. With such definitions, contractors and other producers have attempted to provide the best possible product. Each contractor, each inspector, and each government representative has, of necessity, been required to provide his own interpretation of what we are seeking and how we shall obtain it. Under such circumstances, it seems very understandable that we have confusion, difficulty and many different sets of standards for the same product built in different plants or for the same product ordered by different customers.

Better definition of the words used would considerably improve the probability of problem solution.

Of equal importance is the recognition that quality, reliability and maintainability are closely related with time being the most important variable involved. It appears quite unlikely that QR and M should be brought into one basic product contouring discipline. Since Quality Assurance and Reliability Assurance are also involved, a "QARAM" discipline would offer a major vehicle for management of the problem.

Recommendation

It is recommended to redefine the basic words, quality, quality assurance, reliability, reliability assurance and maintainability in terms that apply across the full range of DoD products; it is suggested that these definitions be derived sequentially and that the QARM discipline be accepted as the management vehicle for solution of this problem.

3. Need for Comprehensive Directives

Most of the OSD and subordinate general directives relating to quality, reliability, maintainability and their assurance are somewhat descriptive of mass production or repeat production of highly complex or high-value items, such as airplanes, missiles, etc. These directives are usually provided by persons well removed from the scene of production, and are sometimes couched in words which have connotation at the seat of the Government which is different from that in use by producers or users. Thus, the directives generally relate to only a small portion of the total product spectrum required by the DoD.

Clearly, there is a need for directives covering the entire product spectrum and, if necessary, supporting directives covering the elements of the product spectrum of particular importance.

Recommendation

It is recommended that DoD review its directives to better define the problem, so that the entire spectrum of products can be properly covered.

4. Need to Know Costs

There exists in the DoD a vague, benign desire to know the costs associated with QARAM. This desire is apparently associated with the feeling that higher assurance efforts (and their costs) will result in higher quality, reliability and maintainability and, thus, a low total cost during the life of the product. There is little understanding or discussion of the trade-off effects of putting additional resources into the production effort versus the assurance effort. There appears to be insufficient understanding that the assurance effort does not add quality to the product, as does the basic production effort.

In addition, none of the DoD accounting systems or information-gathering systems separate out those operations which add value to the

product from those which merely monitor and give added confidence that the product does meet the required product attributes set up by the customer.

Contractors' accounting systems similarly do not often separate these costs accurately. While there should not be a requirement that contractors change their entire system, it should be a requirement that QARAM costs can be derived as needed by the Government.

It, therefore, appears that there can be little opportunity to satisfy this vague, benign desire without a major modification of basic DoD information/accounting structure and the infusion of the trade-off concept as an important consideration.

Recommendation

It is recommended that OSD consider modification of the accounting/information-gathering structure to provide cost information which differentiates between those items which add value to the product and those which monitor or provide confidence-level information; that the DoD require trade-off of asset-utilization between value-adding operations and monitoring operations as an integral part of its cost considerations.

5. Distribution of Assets

Nowhere is there a strong statement of the gains to be made or the reason for application of more assets to the quality and reliability problem area. Nowhere is there a discussion of the time, valuable skill resource conservation, valuable money conservation, etc. The general approach that things will be better if we have more quality and reliability assurance pervades all of the discussions and appears to be the basic postulate on which the entire problem solution is predicated and implementing directives generated.

While there can be no question that all persons involved are well motivated in a desire to improve the efficiency of our product life cycle, there does not exist a clear-cut statement of thinking which could provide the basis for problem solution. This is partly because insufficient cost data exists, insufficient life cycle data exists, insufficient trade-off information for asset application exists.

There is considerable doubt as to the value of requiring more effort be diverted from product generation to assurance functions.

Nonetheless, it is generally accepted that significant gains can be made through a better quality, reliability, and maintainability system.

A major element not clearly stated in current DoD problem discussion, policy, and directives is the increasing rapidity with which technological processes make obsolete the product which is in one of the generation phases, i.e., concepts, research and development, engineering, procurement or prototype testing. Modern technology is moving so rapidly that the old in-series mode of product generation can in general no longer be accepted. This requires major parallel efforts (concurrency) with a high guarantee that quality and reliability obtain at each phase of the product's life, particularly during the generation portion of the cycle. This requires that higher percentages of our assets must be placed in the quality, reliability and maintainability effort to overcome the possibility that quality deficiency would prolong the product generation portion of the cycle. Thus, quality, reliability and maintainability techniques offer a major remedy to the potentially serious consequences of delays which could render a product obsolete prior to its introduction for use in the field.

Thus, on the basis of efficiency and timeliness, it appears that assets should be diverted to increase the assurance of quality, reliability and maintainability in new products, particularly those of high complexity.

The NASA, FAA, GSA and NBS participated in this study. The comments, suggestions and recommendations are equally applicable to those organizations. The reader is requested to mentally add those organizations wherever he reads "DoD" and to add their headquarters wherever he reads "OSD" etc.

Recommendation

It is recommended that DoD formulate policy to guide, for new products, the diversion of assets to assurance of quality, reliability and maintainability.

POLICY

1. Definition of Problem Areas and Solutions

There has been inadequate definition of the QARAM problem, beginning with definitions of the words to be used in discussing the problem. Here, quite clearly, is the requirement for a major policy statement which includes not only the definition of the basic words to be used, but also indications of what is the problem which is being solved, together with ideas or directives as to how it should be solved.

Several documents currently exist which treat a portion of the problem. They are partially overlapping, somewhat ambiguous, and quite often contradictory in that the terms and the connotations of the terms are not the same in each of these documents. There is a need for reducing the many documents to a few.

Current OSD directives on policy do not provide a sufficient statement as to the role, position, resource application, costing, or other basic elements of QARAM. These are needed.

Because of the extremely diverse, tridimensional nature of the QARAM problem within the DoD, it is believed that there cannot be a standardized organization, a standardized application of resources, or a standardized single policy directive which would be specific enough to allow the individual departments or their field activities to operate effectively.

Therefore, it is considered that the DoD policy statement required is one relating to the functional considerations of QARAM; specifically, that the QARAM elements of a product or a system are vital and important to the point that application of the principles involved in QARAM must be identifiable and auditable from the conception of the idea through each successive element of the product producing cycle. This identification and auditability must be defined in the software of the product, the software of the producing systems, the organizational arrangements of the producing systems, and in the position descriptions of certain elements within each of the producing organizations. For certain highly complex products or systems or for organizations whose sole mission is procurement or production it would be desirable to specify a specific QARAM organization.

The Government role in weapons systems continues to increase in relative magnitude as the complexity of the products increases. In previous wars and previous preparations for wars, elements which were in use in the community effort in the social lives of individuals were regularly used--knives, guns, bicycles, automobiles, trucks, ordinary ships, ordinary boats, ordinary planes were used in World War I. With increasing sophistication there was an increasing participation of Government in the conceptual, developmental, producing, and storage phase, even prior to handing the item to a military user. This increasing role has accelerated sharply, after World War II, as the frontiers of technology have been pushed outward and as the modes and equipments of warfare have increased well beyond the frontiers currently being exploited by commercial products.

The new bombers and the associated systems, the new missiles and their associated systems, new submarines and their associated systems, all are well beyond those items which are in current use commercially for the United States social activities. This increasing phenomenon results in increasing requirements for the Government to better define its role in the development of equipments and facilities for conducting warfare.

If the present trend is continued unchecked, ultimately the Government will provide virtually all of the resources and all of the direction as to how these products will be developed, produced and stored. The Government and the producing activity, whether it be private or Governmental, would essentially have to develop its own experience and continue to develop its own techniques. Should this trend continue, it would be expected that the statistics of use which come from spreading a product amongst 190 million people, the experience of many different techniques and technological processes being brought to bear, the experience of many millions of use incidents would largely not be available or used. There is a large additional cost factor involved, as well as the possibility of not being able to develop experience fast enough to insure a satisfactory product.

On the other hand, products such as guns, automobiles, commercial aircraft, etc., do, by exposure to the entire society of the United States, acquire a great deal of statistical experience in use. Obviously, such experience and such knowledge is of great value and is obtained essentially as a by-product of today's society. It appears that significant advantage can be obtained if there is a continual effort on the part of Governmental activities engaged in conceiving and developing new products for warfare, if these products can be pushed from the Governmental and Government-captured industries into the commercial

industry. It appears wise that a policy be developed which indicates the desire of the OSD to continually push the products developed for use of the armed services in the direction of using commercially developed components, elements, sub-systems, etc.

The continued proliferation of splinter engineering discipline or quasi-engineering disciplines from the basic engineering structure of field organizations as a result of DoD emphasis is cause for serious concern. This splintering robs the engineering effort of needed talent, results in over-emphasis of the splinter area, and sometimes degradation of the product. While there can be no question but that certain techniques from time to time need additional emphasis, they are better served when they are provided with the additional emphasis within a basic engineering organization. Since the OSD has no basic engineering organization, it would appear that the splinter contouring engineering disciplines should be gathered into one organization or at least monitored by a management type organization to determine the kinds and amounts of resources which will be applied in each discipline and for how long. Thus the concept of integrated engineering is restated and revitalized.

Recommendations

It is recommended:

1. That DoD revise and reissue its basic policy documents concerning QARAM to improve the policy directive itself and to provide a firm base for the various departmental implementing policy directives.

2. That the OSD policy statement on QARAM include a statement that full identification and auditability for QARAM for each product is required from conception through final use and disposition of the product, such identification and auditability to be clear, through the software of the product, the product itself, the software of the producing organization, the organization of the producing activities, and in the position descriptions of personnel involved in such production.

3. That OSD include in its basic policy a statement which indicates clearly the desire to use commercially developed and proven components, equipments, and sub-systems wherever possible and further, to seek out, where possible, substitution of commercially proven, through use, elements for those elements of systems or subsystems which have already been developed through the Governmental--private industry team working in a warfare area.

4. That OSD include in its policy statements words which will re-emphasize the importance of integrated engineering vice fractured engineering which comes from separate application of splinter disciplines to the product.

2. Definition of Government Role

There are statements of the Government's role in QARAM which contain almost all elements but none contain all of them. Many statements contain only a few elements. It is important that the total Government role be properly delineated in a policy document. This total role involves being a customer, a user, and a monitor, in the broadest sense of each term. As a customer the Government conceives the basic idea, does initial engineering to determine the general description of a product, may then turn over the production of the finalized product to a vendor or a series of vendors, or may do the basic engineering itself and obtain products from vendors to integrate into the larger system. As a user the Government may take partially completed items, fully completed items, tested or untested, use them immediately, store them, and then use them, restore them, and reuse, repair, maintain, etc. As a monitor the Government must monitor not only the commercial vendors who supply products to go into these systems but also must monitor its own efforts. In this last area, monitoring its own efforts, the Government has not been as diligent as in monitoring the efforts of the vendors which supply materials to it. In order to be successful in determining communication modes, organization modes, resource allocations, and the application of management techniques and motivational techniques, to this problem of QARAM in these three major roles, a definitization through a policy document is required.

The use of industrial funding concepts in certain of the Governmental producing activities has resulted in managerial techniques which have in turn provided major sources of cost benefits to performance type budgets, through cost analysis, etc. Naval shipyards, for example, have been so funded for the past fifteen years. Other Governmental activities have been industrially funded. It appears that extension of this principle of industrial funding through more of the Governmental organizations would be of significant advantage, if accomplished in conjunction with the relaxation of conflicting administrative constraints.

There is virtually no limit to industrial funding concept applications if the basic attitude is one of maximum extension. All project-type organizations within the DoD could be industrially funded, for example; the Polaris project, the Minute Man project, the ASW project,

the NIKE ZEUS project, etc. By industrially funding, all costs related to the project could be captured in one convenient accounting system. The accounting system could further be sub-divided into as many elements as desired such as by technological specialization, by commodity, by time of application of resource, etc. By extension of the industrial funding principle, then, costs of various elements of projects, of various specialties, of various disciplines, could be reasonably captured.

In addition, the principle of industrial funding removes from Governmental operation many of the inherent problems which have plagued effective and efficient operation in the past. For example, where there are no charges connected with a service or a product, those who have access to such service or product, clamor for more service, for more effective service, for application of all of the service agencies resources, etc. This is true, for example, in certain of the laboratories; and it is true of various service organizations which are supported from the DoD. Again, for example, the DCAS organization, which services the Army-Navy-Air Force, and other Government activities, is not paid for by the user and the services rendered depend upon the goals set by the administration of DCAS and often are substantially biased by the clamor raised by the using agency. Thus, since there are no costs involved, the squeaking wheel gets the grease. This appears to be an improper way to acquire good service. Further, the activity requesting the service has no way of sending additional resources to the activity providing the services. The activity providing the services, under current concepts, has no good way of acquiring the additional resources to provide the services which are requested by the using organization. Under industrially funded concepts of providing assets, the user of the services pays for those services which he requests and the provider of the service is able to acquire the necessary resources to provide the requested services. His performance to the customer, or user of the service, is that which determines repeats and additional requests for the service. The manager of the service organization is able to attune himself to the customer's needs rather than to the vagaries of an organization direction from above which has no customer response bias. Industrially funded operations almost inevitably operate better than do appropriation funded activities whose loyalties and sources of funds are from above. There can be no question that individual activities and individual persons find ways to provide services under current allotment support circumstances and some of the services are reasonably good. Almost without exception, however, they have been improved when the industrially funded concept of Government operation is invoked.

Field activities do not have a good way of providing career patterns for QARAM personnel nor a good way to move them about from one position to another in slightly different disciplines. Further, management has few incentives to eliminate persons or functions not being fully utilized because of known difficulty in reacquiring assets. Were these problems to be solved, considerable increase in effectiveness would result. There could be, for example, ladder type careers for QARAM personnel from field activities to headquarters to other field activities, etc.; incentive is required for management, for quality personnel and for the organization in general.

Government buying activities have a responsibility for the adequacy of product and are the recipients of user complaints with respect to product deficiencies. Representatives of buying activities have a legitimate purpose in visiting vendors plants. This legitimate purpose is their concern with product adequacy. Their visits must be coordinated with the contract administering agency and their findings must relate to adequacy of product. They should not duplicate the responsibility of the contract administering activity for determining and approving vendor QARAM systems and implementation thereof. Their findings relative to hardware deficiencies may well be traceable to QARAM system deficiency; however, all such comments made must stem from the hardware deficiency and not from primary duplicative review of QARAM systems and procedures.

The problem becomes one of even greater magnitude when Government agencies outside DoD place requirements on the same vendors and find that there is a definite need to frequent the same vendors plant to ensure that the QARAM objectives are achieved. To reduce this need for overlapping of resources and reduce total Government operating costs, there should be a joint DoD and independent agency QARAM functionary that will provide the level of confidence and acceptance in the DoD field activities efforts.

In a diverse spectrum of products such as that monitored by the DoD, there can be no set pattern of operation involving standardized organization, standardized equipment, standardized applications of resources, etc. There can, however, be applications of the basic principles by which men live and acquire superior performance attributes. One of these principles is honesty. This matter is generally handled in a straightforward way and is well understood. Another important principle is that of incentive, which although equally important with honesty, is often not considered and when considered, is often not applied well. Yet incentive is the principle which causes men to do more than merely exist and results in the maximum progression of the human race.

OSD and subordinate QARAM directives are not couched in incentive terms, often they result in dis-incentive. The directives often, as the name implies, "direct" individuals to perform in a certain manner. Direction of this nature is satisfactory in times of extremes, in times of emergency, in certain warfare conditions. However, this does not result in maximum application of human endeavor. On the other hand, provision of incentive almost always encourages maximum human endeavor and maximum progression within the shortest possible time.

Incentive, then, and application of incentive ideas should be a major element of OSD policy statements.

Recommendations

It is recommended:

1. That the Government role as a customer, user and monitor in QARAM be defined in a policy document issued by the OSD.

2. That OSD include in its policy statements that maximum use will be made of industrial funding in its subordinate activities involved in product generation and production; this applies particularly to DCAS. Such use should be in conjunction with the relaxation of conflicting administrative constraints.

3. That OSD study types of incentive to be applied to field organizations to provide management and QARAM personnel with ways of decreasing costs and obtaining gains themselves thereby.

4. That OSD clearly define and delineate the interface between buying activities, contract administration activities, and vendors and provide for the enforcement of the delineation defined.

5. That OSD take action to expand the existing NASA/DoD Reli-Ability and Quality Assurance Committee to include the other interested Government agencies as full members which will provide for face-to-face discussion and resolution of common problems and establish an objective to eliminate unnecessary duplicative activities.

6. That DoD's QARAM policy directives contain, without exception, an element of incentive and that no directive be issued which is not basically incentive in nature.

3. Definition of Vendor's Role

The role of the vendor or equipment producer in the DoD scheme is not sufficiently defined for effective QARAM application. While the policy clearly indicates that the vendor must provide a hardware product which is satisfactory, there are other elements which may be equally important. These generally must be obtained from the vendor through the application of profit or other incentives. For example, better ideas on how to make the product are desired; ideas on how to reduce costs of the product; ideas on how to improve effectiveness of the product, or how to substitute a commercially available element for a specifically designed element. These kinds of ideas need to be extracted from the vendor as part of the normal way of doing business. The current OSD directives regarding the vendor's role and the incentives to the vendor in doing his portion of the job are not explicit, except in a few specific areas, such as value engineering. This lack of incentive description in DoD policy directives makes it difficult for vendors to forward unusual ideas or concepts which would have the effect of improving the product, making it more effective and less costly. Generally, contracting agencies of the Government will not allow the vendor any profit on an item which has been reduced in cost, unless such reduction comes within one of the approved incentive plans. There needs to be, however, an opening of the dam in this regard so that vendors may forward ideas which result in a better product without regard to contract incentive terms with the expectations that such suggestions, if adopted, will result in negotiated cost reductions of the product in which the vendor would receive a portion up to fifty percent. It appears that OSD policy statements defining the role of vendors should include words which provide the vendor with incentive to supply information as to better, quicker, more efficient, more effective ways of performing the same function.

Recommendation

It is recommended that the OSD policy statements include words which would have the effect of providing incentive to vendors to do more than just provide the hardware requested, but provide also suggestions as to better ways to do the job.

COMMUNICATION

1. Directives

QARAM, as used in this report, is an abbreviation for the general areas of quality, quality assurance, reliability, reliability assurance and maintainability.

Basic QARAM terms are not defined consistently. Efficient management of the quality and reliability function within the DoD is difficult because different definitions for the same fundamental quality and reliability terms exist simultaneously in basic directives used by various field activities.

This compounding of the basic communication problem leads to unnecessary lack of uniformity of operation, to inconsistencies in policy, to unnecessary variations in organization and to general confusion.

Some examples of differences in definitions found by Panel 1 in a review of various directives are given in the following:

a. Quality Assurance. "Quality Assurance comprises a planned and systematic pattern of all actions necessary to provide adequate confidence that the product will perform satisfactorily in service."
(From MIL-STD-109A 30 Oct 1961)

"A planned and systematic pattern of all actions necessary to provide confidence that material conforms to established technical requirements and achieves satisfactory performance in service."
(From DoD Directive 4155.11 of 17 June 1965)

"A planned and systematic pattern of all actions necessary to provide adequate confidence that the end item will perform satisfactorily in actual operation."
(From NASA NHB 5330.7 Apr 1966 Edition and HNDBK for Q & RA Procedures and Standards June 1965)

"QA is a planned and systematic pattern of review, audit, and analysis actions necessary to provide adequate confidence that the product conforms to the requirements specified by the customer. Audits of processes and products to assure management that controls are in fact being carried out and results are within control limits, are a part of Quality Assurance."
(From PTSMH NAVSHIPYD INST 4855.3A of 16 Mar 1965)

b. Quality Control. "A management function whereby control of quality of raw or produced material is exercised for the purpose of preventing production of defective material."
(From MIL-STD-109A 30 Oct 1961)

"A management function to control the quality of articles to conform to quality standards."
(From NASA NHB 5330.7 Apr 1966 Edition, Appx G and HNDBK for Q & RA procedures and stds June 1965)

c. Quality. "The composite of material attributes, including performance."
(From DoD Directive 4155.11 of 17 June 1965)

"A matter of conformance of product to explicitly defined requirement, i.e., the goodness of a manufactured item when judged in relation to the procurement package."
(From MUCOM Pamphlet 700-1 of 9 July 1965)

d. Reliability. "Probability that material will perform its intended function for a specified period of time under stated conditions."
(From DoD Directive 4155.11 of 17 June 1965)

"Reliability is the ability of a product to perform its intended function throughout its predetermined life span, under operating conditions for which it was designed."
(From NHDBK for Q & RA Procedures & Stds June 1965)

"The inherent capability of a product (of given design) to meet the performance requirements of the user for the period of time specified, i.e., to perform as intended at desired time under desired conditions. The reliability of an item is generally stated in terms of probability of success under a given set of conditions."
(From MUCOM Pamphlet 700 1 of 9 July 1965)

"The probability that a system, sub-system, component or part will perform its required functions under defined conditions at a designated time and for a specified operating period."
(From NASA NHB 5330.7, Appx G Apr 1966 Edition)

"The probability that material will perform its intended function for a specified period under stated conditions."
(From MIL-STD-721A 2 Aug 1962)

"The probability that systems or components will perform their intended function for a specified period under stated conditions."
(From NAVSHIPS 0900-002-3000)

e. Maintainability. "The probability (when maintenance action is initiated under stated conditions) of restoring a system to its operational conditions within a specified total down time."
(From MIL-STD-721)

"The speed or economy with which a system or component can be kept in, and/or restored to full performance capability."
(From NAVSHIPS 0900-002-3000)

f. Inspection. "The examination (including testing) of supplies and services (including, when applicable, raw materials, documents, data, components and intermediate assemblies) to determine whether the supplies and services conform to technical requirements."
(From MIL-STD-109A and DoD Directive 4155.11 of 11 June 1965)

"The examination, including testing, of contract work, articles and services to determine conformance to contract requirements."
(From ONM INST 5000.3 Vol 2 of 5 July 1963 Chap 7)

2. Recommended New QARAM Definitions

Panel 1, after careful consideration of all material reviewed, offers for consideration the following definitions:

a. Quality Assurance. "A planned and systematic pattern of actions, audits and analyses necessary to provide adequate confidence that product attributes conform to specified requirements."

b. Quality. "A condition achieved by meeting all specified product attribute requirements."

c. Product Attribute. "A visible or measureable characteristic or condition that is capable of being verified at a single point in time. The totality of product attributes must be determined and established to meet the intended end use of the product."

d. Quality Control. "A planned and systematic pattern of those actions necessary for the control of product attributes and the processes that affect them."

e. Reliability. "The continuing conformity, over time, of product attributes, to established requirements, expressed as a probability."

f. Reliability Assurance. "A pattern of actions, audits and analyses necessary to provide adequate confidence that reliability requirements prescribed for the product are in fact being met."

g. Maintainability. "The restorability of product attributes within the specified expenditure of resources, (time, money, manpower, materials and facilities.) expressed as a probability."

Recommendation

It is recommended that the OSD take appropriate steps to insure that the definitions used for basic QARAM terms are standard in all of its organizations. Further, that those definitions provided by Panel 1 in the foregoing be considered in determining what the standard definitions shall be.

3. QARAM Discipline

Many things must occur between the formulation of a new idea and the delivery of a satisfactory end product to the customer. For one, product attributes must be determined by the application of basic engineering concepts. For another, product attributes must be modified to suit customer requirements for safety, reliability, maintainability and so forth by the application of these contouring disciplines.

The QARAM discipline involves the integration and comingling of basic engineering and the contouring disciplines, starting at the begining of the life cycle, so that necessary interplay and trade-off takes place while the basic product is being engineered and developed. This concept recognizes quality as an immediate, measurable condition, achieved as product attribute requirements are met, and reliability as the time extension of quality--a reducing probability that product attribute requirements will stay satisfied over a period of time. Maintainability then becomes a measure of the restorability of product attributes to a specified quality level under stated conditions, expressed as a probability.

Because produce attributes are so interrelated, optimization of cost, quality and operational requirements demands that they all be considered together in an integrated engineering environment which includes the QARAM discipline.

The DoD and implementing military department directives in QARAM are verbose, ambiguous, blurred, extremely extensive and duplicative, yet omissive and defective. There are many hundreds of thousands of pages written to cover the area. There is no question that product

failure has great impact in critical military or civilian applications and every service element seeks to establish the best possible safeguards through definitive specifications and written operation procedures. While applicable to the instant problem, these are generally not acceptable elsewhere because their purpose is not understood. Further, the very extensive nature of these communications makes it unlikely that even the most diligent of contracting activities or contractors could carry them out. It is doubtful that is is possible to understand them. The proliferation of the same idea in many different ways as a result of expanding directives, or the description of the same idea from different elements within the DoD or the military establishments, results in an almost hopeless situation at the product producing level.

The problem is similar to that which existed in the field of procurement before ASPR. There is a great need, therefore, for reducing the number of directives, for making them briefer, clearer, to improve the communication channels. DoD needs a group of technical specialists to coordinate, draft, promulgate and keep up to date one set of clearly written directives on QARAM.

There does not exist today a good QARAM information feedback system which provides to all elements of supervision in the Governmental chain an indication of the efficiency and effectiveness of the control disciplines which have been directed. Communication currently is a one way street from the top down, with no effective information feedback system required or provided through the same channels.

Many other information feedback systems do exist, however, for example, through accounting channels, through defectives reports, through special surveys which are continually being ordered--none of which provide a full picture of the situation as regards QARAM.

Effective communication requires a feedback system which provides the essential elements of the discipline.

To insure feedback requires engineering assistance which is effective in two directions. This is a particularly important requirement in the QARAM area.

Recommendations

It is recommended:

1. That OSD institute a directive review in the areas of QARAM which would result in fewer, briefer, and better directives. Along with such review should be a plan to carefully screen new directives and produce them to the same condition of clarity as is provided by the basic recommendation above.

2. That OSD establish in cooperation with other Government agencies a project group of high level specialists to accomplish the required review and to reform all QARAM and related specifications and instructions into one universal set of directives.

3. That the OSD study the need for an effective feedback system in the QARAM discipline and if a determination is made that such is required, that a group be convened to establish the mode of this effective communication.

4. Collation in QARAM Handbook

A comprehensive, administrative handbook on QARAM is needed. It should include a complete index of QARAM directives and should be compiled and edited by top people.

The quality of material furnished to the Armed Services is the result of teamwork between industry and the responsible Government agency. Quality of the product produced is a function of the design, the manufacturing processes and controls, the ability to maintain under use conditions and to operate under adverse conditions.

Total quality requires an integrated effort from the interface of all the associated disciplines such as QARAM, human factors engineering, maintenance engineering, safety and logistic support.

A DoD level guidance document of the handbook type, integrating the related QARAM oriented disciplines, would serve as a useful tool in the management of many DoD programs. Currently, industrial firms may be doing business with more than one military service or with FAA, NASA, or GSA. It appears advantageous to standardize administrative procedures for QARAM and other interface disciplines and techniques requiring participation by the contractor.

Certain differences will always occur when dealing with Army, Navy, or Air Force, but on the whole, many of these differences are without just cause.

Product vendors have recognized the interface problems associated with QARAM related functions, and many leading vendors manage them for their relatively small range of products with "product assurance"

elements. Integration of these functions permits increased emphasis from management and also encourages a combining and simplification of policy directives, instructions and definitions.

Although the DoD problem is several orders of magnitude more complex than that of a product vendor or system vendor, it is apparent that a DoD level handbook covering the integrated functions associated with these closely related disciplines would have many advantages. General procedures and techniques necessary to influence QARAM programs could be supplemented with certain elements of human factors engineering, safety and logistics programs.

There exists today no good, complete listing of the applicable DoD or service directives which are oriented towards QARAM. These directives are issued in many ways--as DoD directives, military department directives, field directives, as handbooks, instructions, military specifications, boiler plate applications to purchase contracts, specifications in purchase contracts, interpretations as a result of discussion of the provision of inspection requirements in contracts, etc.

It is quite clear that even the elementary listings which have been attempted, including a list of QARAM directives and specifications prepared for Panel 1 use, show the duplication of effort, the lack of clarity, etc. It is quite clear that a complete listing of the various DoD publications of QARAM would assist in reducing the size of the communication problem.

It is apparent that the quality and utility of a QARAM Handbook will depend to a large extent on the capability of the people assigned to its preparation. High level QARAM talent must be made available.

Recommendation

It is recommended that the OSD authorize and direct the preparation of an administrative handbook covering QARAM and other functions associated with these disciplines. The handbook should include policy, general procedures, management concepts, and techniques, a complete glossary of terms for mandatory use by the services, and an appendix listing all of the directives and implementing instructions in the QARAM field. Further that the original preparation and the subsequent up-dating necessary for continued usefulness, be accomplished by personnel with the requisite level of experience and technical capability. Further, that a target date of 1 July 1967 be established for first publication of the handbook.

5. New Concepts on Emphasis

The interface between maintainability and maintenance engineering has not been made clear by the DoD. Maintainability is the restorability of product attributes within the specified expenditure of resources (time, money, manpower, facilities or materials) expressed as a probability. Maintenance engineering is a discipline that provides effective and economical maintenance support through the optimum use of available resources. It is conceivable that the optimum maintainability design would not be optimum design from a maintenance engineering point of view.

When these goals are approached by separate functional elements with no clear cut definition of responsibility, designers are often faced with conflicting suggestions, both intended to enhance the ability to maintain. Through evolution, the newer discipline of maintainability has been permitted to acquire a meaning more descriptive of repairability.

Recommendation

It is recommended that OSD recognize the apparent difficulties associated with implementing a discipline that has been allowed to transgress into both the design function and the support function by clearly communicating in applicable documents its definitions of functions that are clearly within the domain of maintainability and those that belong to maintenance engineering.

6. Information Gathering and Dissemination

There is a need for better access to information about QARAM capability at various Government activities. An effective system should be worked out. It would provide a communication mode of great importance--particularly between DCASR's and using activities. The Personnel Automatic Data Systems (PADS) service (Navy) contains some information on personnel qualification. Perhaps by building PADS, a satisfactory solution could be obtained. The Central Inventory Management System (CIMS) effort, while useful in the long term is too comprehensive in nature to be available within a reasonable time and is not really oriented towards skill-training information acquisition. The Defense Documentation Center (DDC) effort is not effective yet.

There is a clearly established need to acquire, retrieve, and retain information concerning vendor pre-award surveys by various Governmental activities.

Many such pre-award surveys are now being made. Often the survey teams cross each other's path within the vendor's plants or his offices. It appears very necessary that a common system be established to reduce the Government's expenditures in this area, and to reduce the problems of the contractor's in having so many Governmental activities reviewing their operations in the same area.

There is a need for a vendor performance rating and retrieval system. Vendors have often been surveyed and received acceptable marks. Their performance, however, is often unsatisfactory. It appears that it is very desirable to establish a system of vendor performance ratings and to provide a means to retrieve, retain and use such information.

The CPE (Contractor Performance Evaluation) program that has recently been initiated. is a good beginning. CPE could be further developed to include a rating system which would provide through a relatively simple combination of digits, a rating based upon the vendors performance in producing products for the DoD.

There is a requirement for a vendor capability retrieval system. All vendors are not alike. Vendors do not retain the same capability year in and year out as the management changes the direction of the company and as technology produces its impact. There is a need, therefore, to develop information and retrieve and store such information concerning vendor capabilities.

There are many thousand of vendors of commodities, equipments, systems and subsystems delivering products to the DoD. These vendors of all sizes and descriptions provide products to one or more services at different times. Information resulting from surveys and audits is sometimes available to other activities, but seldom is available in sufficient detail and sufficiently categorized so as to be useful to other DoD activities. Therefore, it would appear that significant advantage could be obtained for the DoD and substantial cost reduction obtained if a common vendor capability rating system could be developed and the information provided therein transmitted to a central recording activity. Such central recording activity would be a memory bank which could be queried by DoD and other Governmental activities to determine what rating a particular vendor has.

Obviously, such a central bank of information would have to have the capability of being continuously updated, continuously monitored, and continuously checked for uniformity. In addition, for highly complex systems and high consequence of failure types, the system should

provide information as to how a vendor actually performs in relation to specific contracts.

Recommendations

It is recommended:

1. That OSD establish and maintain a responsive system so that information about the QARAM capability of Government activities is collected, stored, and disseminated as needed for efficient and economical utilization of these important resources.

2. That the OSD develop a system for making pre-award survey information readily available to all Governmental activities in a timely, useful manner.

3. That the OSD study the desirability of expanding the Contractor Performance Evaluation (CPE) Program to include the development and use of a common vendor performance rating system based on numbers rather than adjectives.

4. That the OSD study the matter of a common vendor capability rating system and having determined the necessary elements of such a rating system provide for the acquisition of such information in a central receiving center, such receiving center to have memory capability, inquiry capability and transmission to inquirer capability. To the maximum extent possible, the system should contain information about how the vendor actually performed, not just his apparent capability of performance.

7. Standard Product History Information

In the diverse DoD product area where products are being produced by many thousands of vendors for many different organizations within the armed services, with many of the same basic building blocks such as transistors, O-rings, copper, nickel, etc., there exists the need for a central bank of QARAM information which would pool the various fragmented elements currently available to the Governmental activity product users. Such a bank of information would be of major importance if it could be provided in such a way as to insure prompt, up-to-date transmission of answers to queries about the characteristics of product as acquired, as stored, as used.

It is fully recognized that the development of such a bank of information would be extremely difficult and after experience with the Federal stock numbering system, it might prove to be too difficult to provide a full range of information across the entire spectrum of products used by the DoD and the vendors involved in supplying them. It would be possible, however, for a central bank of information to be

established by technical disciplines which could provide information on vitally important areas and on areas of major cost applications. If the information bank could be restricted in its initial application and if it could provide prompt response, major savings could be accrued.

It must be pointed out, however, that unless the service is prompt and effective, that it will be useless and could be a detriment to the operation.

There is a need within the Government agencies of DoD for a uniform product deficiency retrieval system. When a product deficiency of some significance occurs, an abnormal amount of attention is frequently focused on what may be an isolated incident. By utilizing computer capability, we could exert management control to preclude recurrence and ascertain actual performance levels of in-use products.

Product deficiency retrieval systems exist in some form in most Government agencies, but top management attention has not been focused on the problem of disseminating product deficiency data to concerned DoD entities.

Recommendations

It is recommended:

1. That OSD study the advisability of instituting a data collection operation in the area of vendor QARAM, such data collection to be housed in a central information bank, available to using activities, with particular emphasis on vendor QARAM techniques.

2. That OSD study the desirability of establishing a uniform product deficiency retrieval system.

8. Quantitative Expressions

One of the basic difficulties in communicating DoD and headquarters QARAM policy and directives is that words have entirely different connotations in the various levels of society within the United States, within the various technical disciplines within the United States, and indeed within the various Governmental circles within the United States. As a result the directives, policy statements and implementing instructions put out by the DoD and its subordinate activities require more quantitative expression to be sufficiently clear to insure reasonable understanding and adherence.

There are a number of ways to solve this problem, but the most likely provides for the use of mathematical language wherever such language can be effectively used.

The arithmetical numbers - 1, 2, 3, 4, ... mean the same to all of us. It is possible through the use of numbers to convey ideas which are far more precise than descriptions. Further, equations, whether they be algebraic or otherwise, can provide a full and complete understanding from one person to another. Much of the problem of QARAM is linear in nature, in fact is relatively simple in nature in that one or more elements can be adequately described with an arithmetical series of numbers. Other elements, however, such as in highly complex systems, may require integral or differential equations, or application of higher mathematical techniques.

Most of the chemical, biological, physical phenomena which are used in products are described by equations; most of man's application of energy in machines to products can be described by equations; for example, computer type lathes are tape-fed machines, clearly governed by equations. Thus, it appears quite possible that many of our QARAM type functions could be described by a mathematical type language. By provision of such mathematical language, the inaccuracies would be sharply reduced; the understanding sharply increased. There are many possibilities in this regard.

Recommendation

It is recommended that OSD encourage the use of mathematical expressions wherever practicable in the communication chain of QARAM.

9. Communication Means

We have recognized the many difficulties in communication that arise from the various definitions and connotations found in the written English word. It is apparent that even with our best efforts to improve and clarify written definitions and procedures, we will still have problems in communication. One of the most effective methods of insuring complete understanding and reasonable uniformity in carrying out DoD directives is the face to face discussion provided by conferences. Management must provide guidance and direction through written documentation, but management also must encourage optimum use of verbal communication to insure that uniform interpretation is being made.

Recommendation

It is recommended that OSD make optimum use of face to face discussions and conferences to insure that QARAM management at all levels has communicated effectively.

ORGANIZATION

1. Organizational Concepts

One of the major difficulties in creating, developing, producing, storing, maintaining, and using diverse products is how to organize the different elements in this total product life cycle. Obviously, the same organization that would be useful for thinking would not necessarily be useful for using, nor for storing, and vice versa. The strong elements of disciplined thinking which are so vital in the early stages of a product's life cycle become less important while the aspects of disciplined doing become vital in the storage and use portion of the life cycle. Different organizations are needed and different distributions of resources are required.

In looking to organizational patterns, one finds no universal pattern which would satisfy these diverse needs. It therefore appears that the organizations and organizational setups which are determined to be optimum for the various parts of the life cycle must contain identification and auditability for the important technical disciplines that are involved. QARAM disciplines should be identified through DoD organizations from the commander to the final user of the product. Identification in this case means that important elements of QARAM are written into the organization charts to show a continuous, auditable chain of responsibility from the top of the organization to the user of the end product. The QARAM function in most activities will be that of monitoring and enforcement; even in engineering activities such a function is present in addition to the QARAM disciplines contouring effect on product attributes.

In recent years there has been an increasing tendency for splinter disciplines to break away from the basic engineering of products. For example, value engineering, safety engineering, human engineering, and the like have been removed from the engineering organization of many vendors, many Government activities, and set up in separate small entities outside of the coordinating influence of the supervisors of the engineering function. While there can be no question that emphasis to these important engineering disciplines must be applied, through spectacular techniques from time to time, the continuation of the proliferation of such splinter disciplines into new organizational units can only result in degradation of the final product over the long term. Indeed, today, we see evidence that these separate units, in a fight for survival past their time of usefulness, currently are aggrandizing unto themselves other engineering functions which are not concerned with their splinter discipline. Today, for example, the value

engineering function is aggrandizing management engineering areas. The Zero Defects concept splinter area is aggrandizing various areas of technical responsibility. The splinter disciplines seldom provide balanced reactions to problems, but, rather, proposed solutions which highlight their particular discipline at the expense of the over-all effectiveness and efficiency of the product desired.

There is a vital need that the engineering function be considered in total. All of the basic disciplines must be fully considered for each product. No discipline should be overemphasized in the product, merely because a strong organizational element has been able to subvert the basic product purpose with emphasis on the splinter discipline. Integrated engineering is a vital necessity for effective and efficient products.

It is particularly important that the integrated engineering concept be considered in the organization of field activities, that is, producers, overseers, and users. It appears that the OSD and the military department headquarters in Washington could profit by review of this integrated engineering principle with the expectation that many of the splinter disciplines which have been prolonged too long, oversold by brochuremanship, and press agentry, could be put back into the overall engineering area where they belong.

There can be no question that, from time to time, certain contouring engineering discipline elements require additional emphasis. When such emphasis is supplied, however, through the creation of separate units, separate projects, etc., it is mandatory that the provision for the reamalgamation of that discipline and its associated people back into the integrated engineering group or organization be provided.

Recommendations

It is recommended:

1. That OSD require organizational identification and auditability for QARAM disciplines in the field activities.

2. That OSD include in its organizational concepts a basic requirement that integrated engineering concepts be adopted by field activities and that the organization of field activities adequately conform and implement this policy; that the OSD provide, in establishing projects or units to emphasize splinter engineering disciplines, the time and the mode for full integration of these splinter disciplines into the basic engineering conceptual and organizational operations.

2. Washington Headquarters Organizations

The current OSD organization, particularly its DDR and E and Installations and Logistics components, appears satisfactory to support the QARAM effort if interface conditions are established and supported.

Product attributes are the result of application of basic engineering disciplines and contouring disciplines to the product concept.

Since determination of product attributes is an engineering function, and quality is "a condition achieved by meeting specified product attribute requirements," engineering establishes product quality requirements. Thus, the OSD (DDR&E) is responsible for setting product QARAM requirements, including software.

Attainment of QARAM requirements through control and assurance disciplines is the responsibility of OSD (I&L).

The OSD headquarters organization is composed of a series of separate individual units with no formal intercommunication or intercognizance assignments. Such cooperation and interplay as may be the result of knowledgeable personnel or friendships do transpire within any large organization. There is, however, the need from the DoD for a formalized interplay and for coordination to develop the best over-all direction, rather than overemphasis on one of the minor elements. Within the headquarters organization of the OSD, there is a clear need for an audit capability to internally audit the OSD. Such internal audits would have as a prime purpose, determination of working arrangements as have already been definitized. Such audit would also disclose the many areas in which coordination is lacking and in which the directives which are forwarded to field activities are clearly not optimized for the good of the DoD, but rather for the good of the OSD activity which generated the particular directive. The audit capability in the OSD (Comp) is not considered adequate for this function.

The OSD needs, in addition to its capability to audit itself internally at the headquarters, the capability of auditing the field. Without such audits, there is no way that the management can really determine whether its directives are in fact being carried out, whether in fact they are being understood, whether in fact they can be carried out. The various military departments do provide some audit elements, for example, from the Navy and other military audit agencies, from the GAO, as well as from special on-the-spot, often quick reviews of small portions of problems. There is, however, no complete audit of systems, organizations or disciplines. While it is true that such an audit

plan could, if improperly implemented, result in a considerable amount of additional work in the agencies of the DoD, it is also true that a well organized plan could reduce the total amount of effort required by military departments to support the OSD's efforts. It appears, therefore, that there could be substantial improvement in QARAM operations, at lower cost, if the OSD had the capability for audit of its own activities.

Military department organizations at the Washington level have been made more uniform during the past few years in their titles and their functions. The comments relating to the OSD QARAM organizational structure should apply.

Functional and organizational identification and auditability of the QARAM function is required.

Recommendations

It is recommended:

1. That OSD reaffirm that determination of product QARAM is the function of OSD (DDR&E). The fulfillment of the QARAM requirements is the function of OSD (I&L).

2. That OSD initiate a study to determine the desirability and organizational position of an auditing (management type) group which would internally audit the OSD headquarters operations.

3. That DoD develop and establish the capability for auditing the field activities in the QARAM areas.

4. That the military Service headquarters in Washington adopt organizational structures which provide full identification and auditability for the QARAM function.

3. <u>Field Headquarters Organizations</u>

Field headquarters organizations are generally subordinate elements based on logistics, product support, etc. As a result, they are generally organized to provide support of the basic mission. They generally have and require all of the elements necessary for directing, overseeing, and managing, and occasionally producing various products and systems. As such, they require all of the engineering, production, resource management, and staff discipline capabilities as are required within such places as the OSD headquarters, military system headquarters, etc. An important resource which is required in field headquarters organization is that relating to support of the QARAM discipline. There is a clearly indicated need for a top level, highly skilled

staff whose function is QARAM; to be available to the field headquarters commander to provide advice and assistance in the attainment of QARAM objectives. The identification and auditability of the QARAM discipline should be clear in subordinate organizations.

Recommendation

It is recommended that OSD review the various kinds of field headquarters organizations to determine mission and insure that the basic element and discipline of QARAM is provided at the commander's level in these headquarters with full identification and auditability in the subordinate organizations.

4. Field Component Organizations

Field activities are usually involved with a specific phase of the life cycle of a product, such as development or storage, or use. These units should generally be organized on a phase-mission basis, rather than on a technical or scientific discipline-type basis, but with staff organization having discipline elements in it which support and advise the basic project leadership. What this means is that an organization in the field should generally have engineering, production, resource management, and various supporting staff organizations, all organized to most effectively and efficiently use the products which are the basis for the activity's very life. The disciplines of QARAM should be organized as identifiable and auditable elements through the organization.

Recommendation

It is recommended that field activities be organized along product lifephase lines to support the major mission, rather than be organized by scientific or technical discipline, and that QARAM be an identifiable and auditable element therein.

5. Vendors' Organizations

Vendors of products to the DoD are generally private concerns. They generally organize themselves for maximum effectiveness and efficiency around a product or a particular discipline which they vend as a service. Their QARAM organizations are, therefore, almost always dictated by the kind of product or service they sell. The DoD, however, in acquiring such products, often uses them as elements of a subassembly or as component elements of a larger system assembly. The DoD QARAM requirements are often written to the larger product,

the system, rather than to the elements of the components and the vendors thereby are often required to produce a QARAM organization or system which is not in consonance with the requirements of their products.

It appears, therefore, that the DoD should avoid, where possible, specific definition of the organization or the methodology to be used by a specific vendor of components and small portions of systems, but instead should require that the scope of QARAM be consistent with products' intended use.

Recommendation

It is recommended that OSD, as a part of the QARAM audit program assure the proper level of QARAM application in vendor's organization.

RESOURCES

1. Resource Allocation

Many vendors who supply equipments and components to a multiplicity of DoD contractors are often being monitored by several different contractors at the same time. This surveillance is time-consuming, confusing, and results in unnecessary duplicative effort. As a result, many vendors have suggested that industry come up with a plan for conducting audits of plants by unbiased, separately organized activities, that these audits then be taken as the official determination of the capabilities of the vendor and that these audit findings be recognized by the DoD. These so-called United Vendors Organizations, such as AIA, NSIA, CODSEA, etc., would then be in a position of policing themselves, somewhat similar to a Better Business Bureau. It is believed that this concept is sound and it would, perhaps, provide the basis for far less industry monitoring of vendors, resulting in perhaps an occasional audit rather than continuing surveillance. Further, it appears that as a result of such audits and acceptance by an entire industry of similar standards that the total use of QARAM personnel could be more effectively directed within industry and Government. This kind of approach has the greatest attraction in areas which are ordinarily commercial in nature or have a large application to many products with DoD needs. It is noted that DoD already often uses in its specifications the rules of various private technical groups, such as ASTM, ASME, etc. A combined DoD-Industry study would reveal areas of possible resource saving through this approach.

The allocation of QARAM resources is spotty, and dependent largely upon the understanding by the individual commands of the necessity for the QARAM functions. Thus, it appears that a more effective utilization of these resources could be made with the ultimate improvement in product or alternatively, reduction in costs at the same QARAM level.

A large portion of the QARAM personnel making up these resources are near to retirement age due to the World War II and Korean War "hump." A very serious crippling of the Government's capability could occur if plans are not made in advance to acquire or relocate other personnel.

Acquisition of information about such resources is a difficult task, but one which would not prove impossible if attacked with vigor. It appears that systematic acquisition of information about QARAM resources (mainly people) should be initiated to provide a knowledge

bank of these resources and their capabilities. It is understood that the Defense Documentation Center intends to provide information in this area, but at a later date. Such information is needed now.

Following acquisition of the knowledge bank, allocation of the resources could be better made, provided other information as to the need for such resource reallocation has been made known through the central information gathering and dissemination facility discussed under Communication.

Recommendations

It is recommended:

1. That OSD request industrial groups, such as AIA, NSIA, etc., to join in a study to determine the usefulness of vendors' self-policing in the QARAM field and recommend ways to reduce duplication.

2. That OSD study the QARAM resources available with the understanding that what is needed first is knowledge and second, possible reallocation to acquire better utilization of these resources.

2. Resource Retention

Personnel in the QARAM area do not have career patterns which lead to maximum incentive nor maximum flexibility for effective use in the various organizations within the DoD. Because of this, the personnel do not find ways to move from one organization to another; their capabilities are not always well utilized, but most importantly, all too often they seek advancement or challenge by going outside of the organization. It appears then an overall listing of QARAM trained people would help to a large extent in making known these resources within the DoD, but equally important, it could form the basis for the beginning of a rotational plan for these personnel; such a rotational plan would involve movement from one activity to another as necessary to fully utilize their skills and to make possible for them an advancement ladder which would be attractive in terms of different types of projects, concerns, different geographical locations, different aspects of QARAM. Personnel retention requires heavy use of incentive. Very few, if any, incentives are visible today.

The loss, in a few years, of large numbers of Government QARAM personnel adds urgency to this problem.

Recommendations

It is recommended that OSD study the problem of personnel retention in the QARAM area and develop a series of incentives, including career patterns.

3. Resources Acquisition

There is a need to acquire, train and maintain highly skilled, highly motivated personnel with a QARAM background. These personnel, who do not exist in sufficiently large numbers in the United States, are mainly concentrated in industrial areas involving mass production, multiple production and only to a limited extent in industries which have low single unit production runs. Many of the DoD products are one of a kind or have extremely few numbers in prodution runs, are often modified extensively as production is taking place and many times are highly complex. Under such circumstances it is vitally necessary that the QARAM personnel be of superior calibre.

The OSD establishment in Washington needs additional professional QARAM resources in its activities and operations. In addition, other activities require additional QARAM professionals. These personnel are in short supply in industry as well as in the DoD field activities. It appears, therefore, that a training program will be required to augment the numbers to the proper number required.

Recommendation

It is recommended that DoD increase its efforts to obtain and retain high quality, high performance personnel qualified in QARAM.

DISCIPLINE

The fifth definition of discipline in the American College Dictionary is as follows: "a state of order maintained by training and control." These simple words define a condition which presupposes a number of acts have taken place.

The maintenance of a state of order indicates that there was a concept, a development of a plan, a mode for implementation, a promulgation of a plan, an execution of a plan, an auditing of a plan, and the improvement of a plan; that these acts were performed by personnel of requisite skills, background, training, and desire. Thus, discipline, as used in this context, involves the total operation of doing something and doing it well.

It is an element which is vital to the success of any human endeavor. Some endeavors require more effort than others, some can be done with little or no planning, with little or no need for teamwork in execution, with little or no need for review of the act. But the areas in which the DoD is concerned are increasingly complex, high cost, involving many humdreds if not thousands of people in a very complicated, difficult interplay of individual effort, interaction of machines and facilities under increasingly shorter time restraint. It is in this kind of atmosphere that the DoD must consider the "discipline" discipline.

QARAM has no good plan because of the immense complexity of the DoD spectrum of products, life cycle of products, personnel available, facilities and equipments available. No plan yet exists because of the problems of working into one plan all of these elements.

No plan can exist or be developed until there is a basic understanding that there must be the use of general principles of man's behavior rather than specific application of one or more of the minor techniques or engineering disciplines. Nonetheless, an effort must be made as early as possible to provide a general plan and to provide elaborations of that plan for areas of vital importance at the present time.

It appears that the DoD should begin its considerations of QARAM as a major contouring discipline which biases the attributes of the products which are desired. QARAM includes disciplines which involve the entire system of which the product is a part as well as the product itself. They relate to maximum system effectiveness and minimum system cost rather than maximum product effectiveness and minimum product cost. The plan which is developed for QARAM must take into

account all of the elements of the life cycle and must equally well take into account the probabilities of the capabilities of the people to use the product and the system of which it is a part.

Only bits and pieces of such a plan relating to some elements of the overall problem exist. These, as one would well imagine, are partial solutions and often involve overemphasis of certain elements of the problem. To have discipline, a complete plan must be developed.

Immediately after the concept has been developed and a plan organized for putting it into effect, there is need for development of the implementation phase. This development requires that the entire concept of the plan be tested by mental or actual simulation prior to being put into operation, that the difficulties of putting it into operation be anticipated and ways to work around them arranged, that the individuals who will be implementing are studied to determine that their organizational placement and personalties are such that implementation will be effective. Implementation must be phased for complex products so that the changeover from existing to new can take place with minimum organizational friction and confusion. Indeed, the change from one way of doing things to another often costs corporations and Government activities their vitality and drive and capability--in some cases, never to be recovered, and in other cases to be recovered only after long and painful efforts to crawl back into positions of prominence. In still other cases where a new concept is invoked, the diversion of resources during parallel operations from the old organization and the old method often seriously cripples the activity.

Implementation is a vital part of discipline. It is a part which is almost consistently left out in the OSD directive effort. Seldom, if ever, is there an indication of trial in other than an isolated spot, where the plan is considered to have the best possible chance of success. No overall consideration is given to the difficulties of implementing, nor is implementation actually thought out. This serious lack is fatal in any but a society where the top can enforce its directives. It is always detrimental to effectiveness and efficiency. Implementation of OSD plans needs to be better thought out, detailed, rehearsed and made effective.

Following development of the modes of implementation of a plan, there is need to promulgate it in a way which is clear and effective. This usually takes the form of directives, handbooks, specifications and other kinds of written communications, sometimes implemented by face

to face meetings and conferences to discuss and outline the purpose, the means and the manner in which the plan is to be executed. The promulgation of the plan is an important element for all too often the communications from the development of the plan is faulty, leading to poor execution.

The execution of the plan usually involves field activities far removed from the source of the plan. It involves thousands of individuals, all of whom have a different approach to the problem, a different understanding of the communications and a different understanding of the plan itself. Thus, the execution of the plan may or may not be in consonance with the desired goals of the plan. Execution obviously involves not just the act of individuals in attempting to carry out the plan, but the necessary papers, explanatory memoranda, and other software which define more clearly the subdivisions of the plan into the smallest element. Execution, to be effective, needs to be primarily written to the lowest element of the problem and plan area; the actual do becomes a smaller and smaller portion of the execution as the systems become more complex. The think becomes more important as the problem becomes more complex. The actual do is the direct result of the think.

Since the execution of the plan may not be in conformance with the plans or ideas of those who generated the plans, there is a great need for audit, such audit increasing in need and depth, as the number of activities involved increases, as the complexity of the product increases and as the complexity of the environment increases. Audit is required to determine whether the plan is working, is in fact workable, and to give the director of the plan the necessary information as to progress as the plan is executed. This feedback of information often provides the basis for improving the plan through the iterative technique causing development of changes, i. e., improvements, promulgation, execution and audit again. Successive re-cycling, that is, successive iterations, result in a continuously modified plan which provides maximum effectiveness and efficiency towards the desired goal.

The personnel implementing such a plan at each level--development, promulgation, execution and auditing must have skill, abilities, experience, requisite training and the desire to carry out their part. They must understand the necessity of doing their functions in accordance with the plan. There must be, however, the provision for them to suggest and have implemented their proposals for improvements. This is the incentive to maintaining desire and much of the iterative improvements in a plan should come from the personnel involved in promulgation, execution and auditing to be fed back to the developer of the plan.

Discipline, then, is a combination of a plan and personnel. It is a state of order maintained by training and control.

Such a state does not exist within the DoD today. Because there is no discernible plan (because the plan or plans, if any, have not been promulgated well) good execution and auditing become improbable.

The present state of products in use in the DoD is the result of a fine American industry, strong military department effort in the past and the happy interplay and understanding which has gone on between military and private activities in the past. The OSD headquarters efforts to reduce costs and improve effectiveness have been impressive and have without question produced beneficial results. They have not, however, come as a result of a plan for applying resources to the many disciplines involved in product contouring, nor have they been a product of understanding the importance of basic integrated engineering and the use of incentive, nor of the importance of the "discipline" discipline. OSD concepts need to be subjected to the biasing of the major contouring disciplines, QARAM, among others.

The problem is sufficiently important for a basic conceptual plan to be developed, promulgated, executed and audited for execution of the OSD concepts for product management.

Recommendation

It is recommended that OSD study the matter of the "discipline" discipline in the QARAM field and develop a plan for implementing its needs in this area, promulgate the plan, execute the plan, audit the plan and improve the plan.

INTEGRATED ENGINEERING

The "think" phase of product development all too often is considered to be only the conception and design of the product. Nothing could be further from the realization of the highest effectiveness, lowest cost product.

The "think" phase of product exploitation extends through the entire life cycle, from conception through research and development, through engineering, through procurement, production, storage, maintenance, use and final disposal. The think phase must cover the entire life cycle.

"Think" and engineering are reasonably synonomous in product development; engineering is an inclusive term which in essence says that professional personnel with special skills and training in a particular area will apply their brains in a disciplined way to a specific aspect of a product's attributes.

The product desired is usually defined by a series of descriptive product attributes such as size, weight, performance, reliability, maintainability, etc.; items which can be measured at a specific point in time. From these desired product attributes, engineers with specific training, in structures, mechanics, electrical or electronics specialties, etc. are able to develop a basic product which meets the specifications. They, in meeting the specifications, apply the standard techniques and m[illegible]s of tests with the engineering discipline in which they are involved requires. Thus, a product is born in the conceptual phase in which all of the various requirements of the customer have been considered. This basic engineering phase is that which produces the substance of the product and determines whether there is in fact a product which can be made from the customer's specifications. The basic engineering effort is that which determines a product to the customer's specifications and determines the product attributes, from whence quality derives.

In addition to meeting the product attribute through basic engineering, there exists the necessity to apply contouring techniques which have not yet reached, perhaps, the same validity and credibility as the basic engineering techniques and disciplines but nonetheless, through their growth, have provided additional tools with which the product can be shaped to maximum effectiveness. These contouring techniques require that a product developed in basic engineering be locked at by a successive series of different biases to obtain the best possible product. These successive biased looks need to be taken in an engineering environment; they need to be taken in close time and geographical proximity to the basic engineering development of the product.

Unfortunately, within the DoD a proliferation of the "splintered engineering disciplines" techniques has resulted from special disciplines receiving undue emphasis, or having received proper emphasis, were allowed to continue operations external to the basic engineering development of the product desired. These special splintered engineering disciplines are separately organized to a large extent and maintain their allegiance and their existence to the present time outside the engineering community. In the OSD there is no basic engineering capability; in the OSD, however, there are large numbers of persons, including engineers, involved in promoting splintered disciplines such as safety engineering, value engineering, human engineering, standards engineering, standardization, etc. All of these contouring disciplines are necessary; all of them have their place; all of them are important to the best final product. Unfortunately, however, with the type of organization which exists in the OSD, and is therefore mirrored within the military departments, the emphasis is misplaced often. The resources are often poorly applied and since there is no overall OSD basic engineering capability and little overall OSD management of the resource allocation within the headquarters, the splintered discipline activity which is most persuasive, or has the best brochuremanship, wins additional resources at the expense of activities which need them far more. Further, and most unfortunate of all, some of these splinter disciplines survive long after the problem is no longer acute or long after their usefulness is ended.

A plan is needed by which the contouring disciplines are effectively put into their proper place in engineering development where the resources which are applied can be applied by a predetermined plan, where the resources which are to be maintained within that splinter discipline are subject to continuous review.

There is a need for the people currently involved in promoting splintered disciplines to apply their capability within the integrated engineering framework. Many of these capabilities are not currently fully utilized and could be better utilized in or in conjunction with other engineering disciplines and contouring disciplines. Were they to be reintegrated into the basic structure from which they emerged, the product would be better defined, the product would be better developed, built, and utilized.

There is a great need to reduce to a minimum the splintered engineering discipline effect in the DoD, to establish emphasis on certain contouring disciplines from time to time, but to insure that this emphasis be reduced when the problem has been reduced in scope and to end up with fully integrated engineering of the product. Such an

approach would eliminate the continuing pressures and poor engineering resulting from over-emphasizing certain aspects of the product. Such an approach would result in the best possible design for a product, the best possible plan for its development, acquisition, production, maintenance, storage, and use. Such an approach would lead to substantially reduced costs and substantially better utilization of the manpower assets within the DoD.

The "think" portion of the QARAM discipline, among others, needs to be included in the basic engineering effort for optimizing the product attributes for the product's entire life cycle; these attributes must be contoured by QARAM.

The "do"--enforcement--portion of QARAM is provided by application of resources, organizational planning--above all, it, QARAM, must be fully identified and auditable through the entire life cycle.

Recommendation

It is recommended that DoD reintegrate the current splintered engineering disciplines which are separately organized and supported into a basic engineering structure and that as new contouring disciplines come along, they be emphasized as necessary by management action, but that they not be allowed to go out of the basic engineering structure in the DoD.

INCENTIVE

1. General Discussion

Incentive is a vital and driving force which encourages man to produce his best. It is currently not utilized very effectively, and often not at all, in the OSD QARAM directive system and in its application by field activities.

There is a need to consider incentive at every organizational element. For example, in the OSD itself, what is the incentive to an individual to engineer himself out of a job? What is the incentive for him to do what is difficult and contrary to the desires of his well-intentioned but mistaken boss? What is the incentive for him to persevere in the face of conventional rejection of his idea? What is the incentive to the OSD headquarters as a whole to de-Parkinson itself and to prevent proliferation of people which has occurred while simultaneously the number of units managed was reducing itself? Currently there is little or no incentive to prevent this from occurring. There needs to be. Application of incentive techniques would provide ways of overcoming this particular problem.

In field organizations, what is the incentive to persevere in producing a vitally needed product for which the specifications have been poorly drawn by a senior organization? What is the incentive to change an operating mode which has been prescribed by a senior and has been proven to be ineffective? What is the incentive to eliminate unnecessary mechanics' work at the cost of additional overhead type functions? Field activities have not been studied from the incentive viewpoint. The application of incentive to field activities would produce significant results, but also significant changes in methodology, organization, software, etc. In this connection, industrial funding concepts for Government activities offer a major possibility for incentive application and provide a fine vehicle for institution of incentive applications.

In the contractor's area, many incentives are needed and could be applied. Where specifications, for example, are set too high and cannot be met by any vendor, the vendor who tries the least often is paid the same as the vendor who tries the hardest. What incentive is there for the vendor to give the highest possible approach to a difficult specification? What incentive is there for a vendor to advise a Government activity of similar products being made for other Government activities whose specifications are such that reductions in cost could be made? How about the incentive to a contractor to advise where other Government contracts for a similar product have had value engineering or

money saving clauses applied? How about the incentive of reducing the specification requirement where the vendor is convinced that the product will still be fully adequate for the intended service? There are many ways to provide incentives to the contractor to do a better job; by applying the right kinds and right amounts of incentives, we can get his entire work force thinking about our problem. Application of more thought to our problem, acquisition of more experience through incentive would certainly provide an improved product or a reduced cost product. Further, could we provide incentives by reducing the number of audits for a high quality vendor who consistently remains in the high quality range? Could we provide him with a way of showing his continued high quality, thus reducing the number of audits of his process and his books? Could we provide him with a rating which he could advertise and give him more incentive?

As we discuss incentive, we are also discussing the negative of incentive, i.e., penalty. Penalty has not been adequately utilized within the DoD in QARAM. Penalties are sometimes assessed for lack of performance of the product, lack of timeliness, but they are seldom sufficient to overcome the disadvantages to the Government which these deficiencies have incurred. Lack of QARAM is seldom penalized sufficiently. There has been little systematic consideration of the importance of these elements.

It appears that a study of penalties for nonperformance in QARAM, as well as for nonperformance in time and cost, could produce important gains.

Incentive motivation must consider not only incentive and its negative, penalty, but also its neuter, disincentive and its negative neuter, dispenalty. These latter two occur as the result of poor policy, poor communication, etc., producing an effect opposite to that intended; for example, conflicting directives make it possible to carry out the least demanding, an unattainable specification makes the small effort of one sharp vendor equal to the large effort of an interested vendor if both miss the mark, etc. Disincentive and dispenalty must be wiped out if we are to acquire QARAM through incentives.

Recommendation

It is recommended that DoD reemphasize incentive as a motivating discipline, to be emphasized over the next two years in the QARAM disciplines.

2. Examples of Incentives

Some examples of the application of incentives are as follows:

a. Customer Funding of DCAS Offices. DCAS, an important field activity of the DoD which services all military departments and other Government agencies, is currently funded directly from its budgeting and appropriations structure. In most cases the customer, who really determines how much work DCAS has and what DCAS needs to do, does not reimburse DCAS for the cost of this function except for a departmental assessment. It appears that such a scheme can only result in major difficulties for DCAS in terms of supporting its operations and predicting what will be required and responding to the needs of the individual activities. To give DCAS some incentive beyond that imposed by higher authority in its own chain of command, i.e., the senior DCAS offices and the OSD, to give DCAS some incentive to respond to the customer, it would appear sound to require that all customers fund directly all of the services which they request of the DCAS. By such a funding arrangement, the customer is able to determine how much effort he wishes to have expended by the DCAS and the DCAS also is able to determine how much effort is funded by the customer.

DCAS offices are currently funded directly by allotment using appropriations accounting structure. The statistics upon which operating allotments are provided are often, as is well known, behind the need or the technology or often based on the ability of the individual activity to be heard in the halls of the budgeteers, and, all too often, involve personalities of the individuals making the pleas and those making the determinations. Such a scheme is satisfactory perhaps within a closely confined area such as the OSD headquarters or military headquarters in Washington, but is completely unsatisfactory in a nation-wide effort to cover the entire field of production. Under such circumstances, there needs to be an incentive to the DCAS to provide the requisite kinds of services requested by the customer, but even more importantly, to provide the DCAS with a source of funds which match the work which he is requested to do. Industrial funding meets all of these requirements and it appears that industrial funding would, in addition, automatically provide for the distribution of excess DCAS assets from one office to another. Such a course of action presupposes the relaxation of conflicting administrative constraints such as personnel ceilings, overtime restrictions, travel limitations, etc.

Recommendation

It is recommended that using activities pay DCAS for service rendered; a suggested mode is through use of the industrially funded concept for DCASR offices in conjunction with the relaxation of conflicting administrative constraints.

b. Use of Industrial Funding Technique. Organizations producing material or having an important maintenance or storage function can seldom obtain good information as to cost of these various functions because of the peculiar kinds of accounting which are forced upon them and the financial support which is made available to them, not by product, not by technical disciplines, but rather in accordance with an appropriation structure which is geared to the need of the legislative body and the budget directors and executors in the Washington headquarters. Until an accounting system is implemented which does provide for adequate striation of charges so that costs of QARAM and other technical disciplines can be obtained, significant progress will not be made. Major gains could be made by adopting the industrially funding concept, not only for naval shipyards where it has been in existence for fifteen years, but also for all types of project organizations and field organizations whose primary function is to produce or store materials. Industrial funding techniques provide major incentive to managers by providing them with resources to match the needs of the customers and providing them with costs to show wherein the money is being spent.

Recommendation

It is recommended that OSD provide for maximum utilization of the industrial funding technique as an incentive device for field managers.

c. Funding Guidelines. There is at the present time no guidance provided to field activities nor to their field headquarters as to operating percentages of funds which should be devoted to QARAM. This difficult question has not really been addressed by any of the multitudinous DoD directives, handbooks, etc. Indeed it is not a question which can be answered by flat percentage. However, by describing and categorizing products, it is possible that operating ranges for QARAM could be established and if satisfactory accounting systems were simultaneously developed, percentages to be applied to QARAM would fall within a reasonable range for certain kinds of products. Some of the DCAS operations have generated information on DCAS quality costs which could be included in such an effort. Were these percentages or goals to be established, there would be incentive for

managers to find ways to improve their operations, either quality-wise or cost-wise. At present there is no such incentive since QARAM is, by direction, virtually entirely an overhead function and is not separated out in costs, and in many areas, is not sufficiently emphasized.

Recommendation

It is recommended that where industrially funded operations are not feasible, OSD establish the operating ranges for funds devoted to QARAM as an incentive to field managers.

3. Government Field Activities

There exist within the Government many incentive programs. These are generally departmental in nature and do not survive well the transmission crossover from one department to another (Beneficial Suggestion Program, etc.). Similarly, specification revision programs appear effective intradepartmental, but relatively ineffectual in an interdepartmental sense. Since interdepartmental effort is sharply increasing, this aspect to incentive programs must be emphasized.

In the QARAM field the interplay between the DCS, DCAS (DCASRS), military departments and military field units makes such action highly desirable.

As the nation's products become more complex and as professional and technical societies become better organized, the major industrial concerns in the United States are being brought closer together in terms of QARAM. There are many audits of vendor organizations by the Government activities. There are also audits of vendors' operations by commercial activities, for example, in the automobile industry and the aircraft industry. Little use has been made by the Government of the vendor audits which have been made by industry for commercial products; much use could be made of such audits. It would be necessary, of course, to transfer such audit information from the substance format set up by the commercial activity to that required by the Government. A simple transposition from one form to another is all that is required in some cases. Substantial savings could be obtained by the Government in reduced effort and substantial savings would accrue to the vendor were commercial activity product audits utilized where applicable. This incentive to both Government and vendor in terms of reduced costs and reduced time could be substantial in the complex industry area.

Further, and perhaps more important, many vendors are subcontractors to several prime vendors, and provide material to many

Government sources. These vendors are in a constant state of audit often with many contractor auditing teams in plant at the same time. The resulting interference, confusion and cost is not in the best interest of the Government, since the Government pays the costs of audit eventually. Clearly, reduction in such audits by Government action would be in the Government's interest. Some reversion to Government certification might be desirable. In any event, a thorough study of this situation is necessary.

Recommendations

It is recommended:

1. That OSD review incentive programs emphasizing their interdepartmental elements.

2. That Government contracting and overseeing agencies use commercial activity audits of vendors insofar as practical. Further, that a study be made by OSD to determine ways in which replicative or simultaneous audits of a vendor for the same purpose could be reduced.

4. Vendors

While value engineering concepts are well understood in Government and industry, some of the other incentive modes are not particularly well understood. One of these, for example, is the similar product savings concept. Vendors often receive requirements from Government activities for products whose attributes are quite similar in most respects to products already ordered by other Government activities or in use in commercial areas. While there is currently a pre-award survey requirement for "similar product" review, after the survey there is no incentive for the vendor to go back to the purchasing agency and advise that he has a similar product set up for production which, if production run is increased, could result in substantial savings to the Government, and possible higher profit to the vendor because of reduced management attention, reduced overhead on the separate and different products, etc. There is no provision currently for any savings of this type to be passed on to the vendor and since there is no incentive to him, seldom will he or can he take the time and effort to advise the contracting agency that his already produced product is adequate. It would therefore appear prudent to consider a "similar product clause" in contracts which in essence would call for the contractor to provide to the contracting agency advice as to similar products which he has under production or has produced which could serve the same purpose intended by the contracting agency and at a considerably lower cost. Such savings, should the substitution be accepted, could be split on a formula basis.

The opposite end of the incentive spectrum is penalty. Penalties are well understood in industry, and in law, but they are not well implemented in Government contracting procedures, particularly penalties for failure to meet QARAM provisions of contracts. The reason seems to involve in specifications which are not clear, or first-time products, areas in which the Government of necessity makes changes, etc. Nonetheless, there can be better utilization of penalties as an incentive to meet specifications. Certain Government agencies require contractors to pay re-inspection costs and/or costs incurred when Government inspectors are called out, but the contractor is not ready. There needs to be added penalty for failure to meet QARAM requirements where such failure results in substantial added costs in the final product, (for example, where the element purchased is an element of a sub-assembly and the total sub-assembly is degraded by the unsatisfactory product received from the vendor). These penalties will be hard to determine and enforce, but can and should be attempted.

In all penalty assessment QARAM personnel play a large role and must be required to formally provide deficiency information to Government contracting and contract administration personnel.

Recommendations

It is recommended:

1. That the "similar product" savings approach to providing material be studied by OSD and where applicable be included in standardized contract forms with a formula split savings clause.

2. That OSD enforce the application of penalties provided for failure to meet specifications, particularly in the QARAM area.

5. Career Patterns in OSD

Career patterns for personnel in the QARAM areas do not currently exist in the normal sense since this technology is relatively new. There are great needs, there are insufficiently allocated resources. The resource application is being hampered by lack of an adequate career pattern, indeed by a lack of adequate information as to what are the QARAM personnel requirements of the various military departments and the DoD. For a career pattern to be developed which has significance there needs to be experience; field, headquarters, vendor--the complete gamut of experience, there needs to be refreshening of such experience. Career patterns for QARAM discipline people are important and could result in substantially better utilization of the insufficient resources in this area which we currently have.

The possibility of interchange of Government and industry QARAM personnel should be studied as should the possibility of advanced degree study during a sabbatical year. Career patterns for QARAM personnel should be developed to provide incentive.

Recommendation

It is recommended that OSD study suitable career patterns to provide additional incentive for DoD QARAM personnel.

6. Personal Accountability

The elimination of personal accountability in DoD organizations is working to the disadvantage of DoD--it is a disincentive to the individual. For example, the old method of identification of the inspector by name or number was a positive incentive through personal accountability. It should be restored. (The DoD Acceptance and Inspection Stamp could be modified to provide such.) Similarly, major efforts should be made to develop concepts and plans for personal accountability throughout the QARAM discipline.

Recommendation

It is recommended that DoD require personal accountability in the QARAM discipline as an incentive to improved performance and an aid to auditability.

7. Disincentive

Perhaps the most discouraging portion of the entire operation is the inadvertent use by all echelons in the DoD and its components of disincentive and its opposite, dispenalty. Disincentive continually saps the organization of the vitality which is brought by enthusiasm, interest, and proper use of incentive. There are many, many indications of disincentive throughout all operations. For example, the overemphasis of certain elements and certain techniques by DoD directive or departmental directive. Currently, for example, the very important value engineering concept is being debased by unrealistic goals and overemphasis, leading people into shoddy practice. Again, since the headquarters value engineering personnel involved are now looking for more things to do, they are spreading out and aggrandizing unto themselves other engineering elements. The same is true of Zero Defects, a very valuable program which has been prostituted by the improper use of words and the improper application of the term "Zero Defects" to people who merely say they will try to do better. Disincentive here is

considerable. Of perhaps more demoralizing effect is an area in which the responsibility for turning out a satisfactory product, or using it, has been laid upon an activity and simultaneously many directives, by function, by money accounting or by personnel accounting remove from the activity the basic capability of doing the job properly. The continued diversion of more resources to the Washington scene is often a disincentive to field activities who do produce in essence the entire product of the DoD.

There is considerable evidence of dispenalty, too, in our acquisition operations. The vendor who produces a product which is very close to the specifications often receives the same penalty as the vendor who produces a product which is far below the specifications. Both have missed the mark; therefore, both receive the penalties. The vendor who has a strong QARAM organization, good records and knows all of the details of his product often receives more specification departure notices than does the vendor who knows nothing about his product and has no records. Dispenalty continues to result in opportunities for the marginal and sometimes unscrupulous vendor to operate to the detriment of the total program. We need to consider the matter of disincentive and dispenalty seriously and remove it from our operations. Dispenalty and disincentive are the neuter of incentive; they can produce nothing--they can only give us difficulties.

Recommendation

It is recommended that the disincentive and dispenalty aspects of operations be removed as they are discovered by field activities and the DoD.

8. General Incentives in DoD

The need for attention to the incentive concept and approach is not restricted to QARAM. As a result, we feel a need to discuss this subject in a broader context.

a. OSD. There is currently no incentive within the DoD, either at headquarters or in its field activities, for a job to be eliminated by the incumbent. While there is some incentive for some levels of management to eliminate jobs, particularly for those organizations which are industrially funded, there is no incentive currently provided to the individual to engineer himself out of a job. On the contrary, every influence works the other way. Civil Service grade structure requirements often relate to numbers of people supervised, thus, usually tending to build up an empire. Further, since the individual has no place to go should he engineer himself out of a job, he is concerned

about making a living after moving along. It appears that there could be substantial incentive for job elimination, however, if management would address itself to the problem. There exists currently as a result of the base closure system, a major DoD referral system of jobs at all levels. This referral system will of necessity be kept going for many years because of the phaseout times for the various activities designated for closure. The use of this referral system and the freezing of certain job opportunities in it would offer the high probability that any individual who engineered himself out of a job could have a similar job, or a job which would utilize his talents, available to him within a relatively short time. Further, since the problems that exist are almost always greater than the resources which we have, there could be set up a pool where people who engineer themselves out of jobs could be utilized on specific problems pending acquisition of job opportunity which they might wish to accept. The basic problem, however, is how to get a man to engineer himself out of a job. There is no incentive presently. There could be one. For example, set a year's pay as the incentive, half of which would go towards paying for six months leave for the individual to do as he wished--vacation, study, travel, etc.; the second six months would be set aside for training for a new job so that in effect the individual would then have a sabbatical period followed by a retraining for a new job. Such incentive, together with a centralized referral system could result in substantial job reduction by engineering by the job incumbent. Other incentives, such as flat-out case payments, could be used, but since they would not provide the individual with a re-entry into the system they might not be as effective. In any event, incentives for engineering oneself out of a job are needed in the DoD.

b. Washington Headquarters. Incentive for military department headquarters in Washington is a most difficult area. It is difficult to industrially fund such headquarters, it is difficult to acquire sufficient resources to make them as fully responsive as they would like to be, it is difficult to find measurement techniques which indicate their effectiveness or efficiency. Therefore, it appears that special incentive studies are needed to determine how the Washington military department could be incentive guided. There are obviously many routine incentive type systems--the Beneficial Suggestion system, the Value Engineering system, etc.--but these all work at the technology, the resources and few of them get to the heart of the matter of what does it cost to provide a Navy or an Army or an Air Force. The cost effectiveness studies which have been made can only be based on a reasonable number of assumptions; unfortunately, such assumptions are not always based, nor can they be based, on what the next year's enemy will actually do. Cost effectiveness studies can only be a first approximation of what is needed and how funds should be spent.

Similarly, OSD headquarters does not operate effectively using incentives. It has grown over the years from a few hundred to many thousands of people. Despite its growth in people and proliferation of high grade structure, it has not yet acquired the resources nor the organized management which it so sorely apparently needs. The resources which it currently has are ineffectively spread out through many different organizations and are, unfortunately, often involved in power struggles because of the poor definitizations of what is required for today and the future. There is, of course, considerable knowledge of what has occurred in the past; however, this is not a complete basis for organization of application of resources.

The big question is, how can the DoD eliminate Parkinson's Disease, of which OSD headquarters is, perhaps, a typical example? Are there techniques for organization, are there techniques for modifying Civil Service rules, are there techniques for job description writing which would permit managerial engineers to move from place to place within the organization? Is it possible, for example, to allow an engineer to become a general engineer at the GS-14 level instead of a mechanical engineer or an industrial engineer or an electrical engineer, and have a large proportion of the engineers in a common pool where they could be moved from operation to operation as old projects are completed and new projects are begun? Would it be possible for PL-313 personnel to be moved about in a similar way? Unless some way of cutting the knots which developed from the current Civil Service position description empire-building operation is found, there seems to be no course for the future but that the DoD headquarters grow and grow and grow as the systems overseeing becomes more complex. It appears that there could be substantial improvement in the management of the DoD if an "incentive engineering" management approach were taken, with resulting recommendations to modify the manner in which the department is organized, the manner in which it attacks problems and the manner in which it currently fails to provide incentive to its people resources to move, to move rapidly from project to project to apply resources to the jobs that need doing. It is a fact that the areas which are best staffed are those areas where the problems are substantially over. The areas which are most poorly staffed are those in which the problem is maximized and getting larger. Something must be done to improve this situation.

c. Field Activities. Field activities, like the central activities, do not have a good way of providing career patterns for personnel, do not have a good way to move personnel about from one position to another in slightly different disciplines, and, above all, management has few, if any. incentives to eliminate, temporarily at least, persons or functions which are not being fully utilized because

of its known difficulty in reacquiring assets. It appears, therefore, that significant gain could be obtained if, in the field of QARAM, identification of individuals with these capabilities was made, that they could be made available to other activities when their own activity does not have full use; further, that career patterns, which provided for ladder-type activities, etc., would be provided, and, finally, that a de-Parkinsoning device be established. Incentive is required for management, for QARAM personnel, and for the organization in general.

Recommendation

It is recommended that DoD make a study of the broad application of the incentive approach as a means of improving management effectiveness and resource utilization.

REPORT OF PANEL 2

TITLE: Quality and Reliability Management in the Development Phase

OBJECTIVE:

To improve the methods within the Department of Defense of establishing requirements for and obtaining materiel with the required quality and reliability during the development program.

TOPICS DISCUSSED:

1. Adequacy of Operational Requirements

2. Stratification of Inherent/Operational Characteristics

3. Reliability Demonstration Requirements during Contract Definition

4. Reliability/Quality/Cost/Time/Performance Trade-offs

5. Storage Degradation Factors as Design Parameters

6. Incentives to Minimize Adverse Reliability and Quality Trade-offs

7. Parts for High Reliability/Long Life Applications

8. Time Phasing of Reliability and Quality Assurance Functions in the Program Cycle

9. Specifications and Specification Guidelines

10. Resources for Advancing Reliability and Quality Technology, Reliability and Quality Programs, and Reliability Demonstration

PARTICIPANTS

Chairman	Mr. George S. Peratino, HQS, USAF
Panelists	Mr. Paul Miller, SPC, Navy
	Mr. R. B. Bussler, NAVAIRSYCOM
	Mr. Charles Tantillo, DCASR, New York
	Mr. Erwin O. Kruegel, HQS, DSA
	Mr. Howard M. Weiss, HQS, NASA
	Lt. Col. Gerald Ledford, HQS, Army
	Mr. A. W. Rogers, Army Electronics Command
	Mr. Martin B. Broude, FSS, GSA
Recorder	Maj. John G. Skidmore, HQS, USAF
Monitor	Mr. Seymour J. Lorber, HQS, AMC

ADEQUACY OF OPERATIONAL REQUIREMENTS

Many Operational Requirements do not contain comprehensive statements from which realistic requirements can be derived for the attainment of the necessary quality and reliability.

The Operational Requirement (SOR, QMR) is a document by which the Operational Commander states the need for the development of a particular operational capability. Normally, it follows and is based on the information in a Proposed Technical Approach (PTA).

The PTA is a document prepared for the Operational Commander by the developing command outlining technical approaches by which a particular capability may be achieved. Proposed technical approaches provide a major source of information required by SECDEF memo of 16 August 1961 concerning possible trade-offs between cost and performance, and between lead time and cost for use in RDT&E planning. The PTA may be submitted in response to a General Operational Requirement (GOR, QMDO) as an unsolicited proposal to call attention to possibilities for a warfare system resulting from advancing technology or in response to a Tentative Specific Operation Requirement (TSOR, DPQMR) as a solicited proposal presenting alternative approaches to attain a capability.

The TSOR or DPQMR is a document originated by the operational commander and addressed to the developing command or bureau. The TSOR or DPQMR provides increased amplification and detail concerning a particular operational capability need which was stated in general terms in the GOR or QMDO. The TSOR or DPQMR is an official request for certain information required by the operational command to understand better the scope of effort and resources needed to achieve a particular capability. Promulgation of a TSOR or DPQMR does not establish a firm service requirement and does not authorize the commencement of a new development program. The TSOR or DPQMR states a tentative requirement for a particular capability, identifies the anticipated or existing threat, defines those performance and operation characteristic envelopes which can be specified, indicates the time period in which it is envisioned the capability is needed, and usually states the number of systems which will be required.

The TSOR or DPQMR is a step toward arriving at a definition of a system; its characteristics; its development; and its cost of procurement, operation, and maintenance. It is a means for comparing the effectiveness of a proposed system with alternative methods of accomplishing similar missions.

Recommendations

It is recommended:

1. That operational commanders should be encouraged to include in their statement of requirements operational information that affects reliability and maintainability design.

2. That during the conceptual phase, the reliability and maintainability requirements should be refined by analysis and study of alternatives. After the SOR or QMR is promulgated, trade-offs should not be made without a complete analysis and synthesis comparing all the alternatives in the original Proposed Technical Approach and others that may have become feasible in the interim. The operations research analysis (operations analysis, systems analysis, operations evaluation study) on which the Proposed Technical Approach is based should be made available to engineers for translation into engineering requirements suitable for contracting.

STRATIFICATION OF INHERENT/OPERATIONAL CHARACTERISTICS

The absence of adequate degradation data and its effect on inherent engineering characteristics makes it difficult to establish inherent characteristics that knowingly will meet the needs of operational deployment.

The proof of how well systems and equipments meet operational requirements must await issue to operational forces and is at that time measured and reported in the materiel readiness posture. The user, as drafter of the requirements documents, the Qualitative Materiel Requirements in the Army and the Tentative Specific Operational Requirement in the Navy, and the Required Operational Capability (ROC) in the Air Force, thinks primarily in terms of these operational requirements and not in terms of the pure inherent requirements as differentiated in MIL-STD-721A and MIL-STD-778, now being combined as MIL-STD-721B. The operational requirement, which has as its baseline the inherent characteristics, is complicated by the addition of all the factors of the real world such as morale and individual competence, state of training, efficiency of the logistics system, the administrative system and the quality of the production item. These complicating factors are recognized variables, many with wide deviations and most with unmeasured or unknown central tendencies.

The developer, as the initial entrant in the acquisition phase, deals primarily with the inherent characteristics of systems and equipments. These characteristics can be predicted, apportioned, and measured in demonstrations and controlled tests. Those characteristics such as inherent availability, reliability, and to a lesser degree maintainability, have accepted scientific basis on which to predict results as opposed to a now existent or limited empirical base for those variables that add up to the operational characteristics. It is these inherent characteristics that the developing agencies can consider in trade-offs along with other performance characteristics in a matrix that includes time and dollars. The developer can trade-off inherent reliability levels by adjusting the testing accomplished during development in favor of time or money, or both, as an example. The developer does not have the K factors that degrade the inherent characteristics and are present in the operational characteristics. This problem is real, not always recognized, and at times leads to misunderstandings between the developer and the user because of the differences in the baselines.

The developer, in his modeling and trade-offs to arrive at an optimum model, can and does influence many variable K factors by the nature of his design. If he fails to recognize that there is a Murphy's Law or to properly consider man-machine relationships in human engineering, he may produce a product that will have unanticipated failures in the field that places undue burden on the logistics system and in turn degrading the readiness posture. An example would be dependence upon the operator to operate a piece of equipment at the proper speed to avoid damaging the engine as opposed to providing a machine governor that would prevent engine runaway. On the other hand, the design specifications can require tolerances of fit or characteristics that are difficult in manufacturing, increasing the quality assurance problem, and in extreme cases negating field and depot repair. These affect production, procurement, and the stockage position

K factors associated with logistics, administration, and other influencing actions need to be determined and understood for systems and equipments before the user and developer have a common baseline for translation into realistic requirements. Then, trade-offs can be more intelligently assessed and decisions made on alternatives. A reporting system that will complement the K factor determination is a necessity.

The Army, in connection with HAWK missile system, has had some encouraging experience with isolating mean logistics time from inherent time, which hopefully can be translated to the SAM-D stated requirements.

Recommendations

It is recommended:

1. That an examination be made of existing data reporting systems to determine their capability to stratify the inherent and operational characteristics.

2. That K factors associated with the operational use of selected combat systems and equipments be defined.

3. That the services establish or place more emphasis on assurance programs that will minimize the degradation of inherent reliability of the design during the production, operational deployment and logistics support of military systems and equipments.

RELIABILITY DEMONSTRATION REQUIREMENTS DURING CONTRACT DEFINITION

Reliability demonstration requirements (tests and confidence levels) are not adequately defined during contract definition and early development.

The publication of MIL-STD-785, 30 June 65, for mandatory use by all departments and agencies of the DoD, provides reliability programs for the design, development, and production of systems and equipments. It furnishes uniform criteria for reliability programs and guidelines for the preparation of detailed specifications and contract work statements. At the conclusion of contract definition the contractor should furnish the government with a Reliability Program Plan which will include provisions for the following:

1. Development and Qualification Testing.

A planned and scheduled program of functional environmental testing of equipment to be conducted during design and development phases t estimate achieved reliability and to provide feedback of data as a basis for making reliability improvements. The development testing program will confirm adequacy of selection of units and parts, determine capabilities and safety margins, evaluate drifts of component parameters with time, establish human performance operation and maintenance variability criteria, and determine failure-modes and relative failure-rates. Where such data are not available, all items of the system determined by the reliability studies to have a significant bearing on inherent reliability will be tested early in the development program.

2. Environmental Testing.

A program for development, qualification, and acceptance testing to be based on maximum environmental stress conditions as specified by the procuring activity. When such environmental criteria are not specified, estimates will be made of environmental factors from experience on past programs. The program will be planned to permit evaluation of adequacy of design of equipment for the expected conditions in the use-environment (e. g., ground operation, launch, flight, orbit, etc.) and include such considerations as: (1) equipment location, shock-mounting and truss-mounting; (2) environmental problem areas at the system, set, group, unit, and part level; and (3) the effects of these problems on system reliability. Additional testing of critical items such as life testing, failure mode testing, and tests to determine adequacy of safety margins, will be submitted for approval.

3. Part Testing.

Parts to be used in the equipment will be assigned a reliability index, failure rate, or expected probability of failure under the application of stress levels. When these data are not available, they will be sought through parts testing. The testing specifications and reliability test procedures of military specifications for similar parts shall be used. Reported measures of achieved reliability will not be based upon short duration tests which predominantly measure performance. Where time does not permit adequate testing at advanced ages, the actual range to be tested will be stipulated. Plans for maintaining a current record of the results are required. The test data will be retained for a minimum period of 2 years from completion of contract.

4. Reliability Demonstration.

a. Initial Plan. An initial plan for demonstration of achieved reliability at specified milestones, including planned number of test articles, accept/reject criteria, and the associated confidence levels will be provided. The initial plans for demonstration of reliability should include trade-off curves showing number of test articles and operating test time or test effort versus reliability and associated confidence and will encompass testing at the system level, and subsystem or unit levels, separately and in combination.

b. Final Plan. The final plan for demonstrating achieved reliability will provide for including any revisions to the initial plan, and the ground rules and criteria for deciding whether a test shall be classified as a success or failure, or whether a test shall be excluded due to invalid data, or other factors interfering with established test conditions. Reliability demonstration plans will apply all results of testing and operations from which valid reliability measurement or assessment can be obtained. Engineering tests and analyses, e.g., test-to-failure concepts, are appropriate to supplement statistical reliability test plans. The milestones at which contract compliance is to be demonstrated shall be recommended. The time for the submission of the final plan for reliability demonstration shall be designated as an overall program milestone.

c. Test Plans. The test plans contained in MIL-STD-781, when applicable, will be applied. Any other reliability test plans proposed shall be detailed with regard to sample sizes, duration of test, confidence level, conditions of test, accept/reject criteria, etc. Failure rate sampling plans such as outlined in MIL-STD-690A are a good example.

From the preceding it is evident that there are existing provisions that adequately outline requirements for tests and demonstration down

to the parts level. The criteria for stated reliability requirements should be subject to trade-offs by the contractor during contract definition and should be considered as a step in the refinement of requirements.

Recommendation

It is recommended that the requirements of MIL-STD-785 be adequately detailed during contract definition and in all succeeding program phases.

RELIABILITY/QUALITY/COST/TIME/PERFORMANCE TRADE-OFFS

Standardized procedures for collecting quality and reliability data, and procedures to effect trade-offs with program costs and schedules are inadequate.

The Final Report of Task Group IV, Cost-Effectiveness Optimization (summary, conclusion and recommendations), Weapon System Effectiveness Industry Advisory Committee (WSEIAC) recommended that the Air Force should identify those elements in cost-effectiveness analysis on which further research must be done to increase the utility of the approach to system evaluation and to improve the tools for performing cost-effectiveness analyses.

Reliability is recognized along with other performance characteristics as effectiveness elements that can be expressed as variables in mathematical models, subject to trade-offs and optimization. Theory of cost-performance relationship is known among System Analysts and Operations Researchers and treatises can be found in published literature on methodologies and analysis techniques, but much research still needs to be done in this area. In actual practice the marginal cost associated with incremental changes in reliability is difficult to compute and as a consequence has not generally been included in mathematical models to the same extent as other performance characteristics.

Very little can be accomplished without data. The analysts have been hampered by the lack of data associated with acquisition and ownership costs. These latter costs are probably the more important to any reliability trade-off. Case studies have shown equipment to experience total costs of one order of magnitude greater than the original acquisition cost during the remainder of the life cycle.

It is recognized that reliability built into equipment at the time of design is attainable at the least cost. The developer is faced with providing a myriad of effectiveness characteristics, all of which have a cost and time associated with them. Unless the developer is aware of the incremental costs associated with reliability he will give this characteristic the back seat in favor of other characteristics he feels are more tangible and attainable within his time/budget. In essence he doesn't always know what he can get for his money in reliability.

A major problem confronting the military services today is the lack of factual data on the reliability built into existing systems and equipments. Of the equipment in the field today, little is really known of the

mean-time-to-fai ure. This is understandable when we realize that contracts until re ently did not require quantitative reliability levels to be demonstrate . Field data reporting under the Air Force's Manual 66-1, Maintenance Management and The Army Equipment Reporting System (TAERS), have been in operational use for several years. The reports issued did not furnish reliability data for the systems or equipments. Another progressive step is the Air Force IROS (Increase Reliability of Operational Systems) Program, where meaningful reliability data is being acquired by determining true failures occurring in operational systems and developing K factors to arrive at actual operating hours. Without a data base, comparative analysis between existing and proposed equipments and the determination of what reliability can be reasonably expected in the future evolution becomes hard to pin down.

The data base is progressively becoming better, both as to cost and reliability figures of merit. In time, analysts will be able to determine break-even points, and cost-effective trade-offs will be more meaningful in the reliability-quality area.

Recommendations

It is recommended:

1. That continued research be sponsored by the services in improving cost-effectiveness techniques and modeling which consider reliability and quality as elements of effectiveness.

2. That all services continue their efforts to refine pertinent data and techniques for use in cost-effectiveness trade-offs.

3. That management ensure utilization of reliability-quality cost-effectiveness trade-offs in the decision making process.

STORAGE DEGRADATION FACTORS AS DESIGN PARAMETERS

The development of reliable systems and equipments is hampered unless storage degradation factors are available for use and application by the designer. Current techniques are inadequate.

Reliability of systems and equipments begins during the design phase. Considerations at this time include environmental conditions, mission requirements, storage and expected life, and the maintenance and logistics concept. The designer must select materials that will satisfy the above conditions and requirements. This phase within the life cycle is crucial to equipment since its physical and performance characteristics are being roughly molded. During the development period, many tests are conducted that must be correlated to the mission and environmental requirements of the equipment.

The designer in the selection of material that must withstand changing environments over extended periods of time is often hampered in his development test by the lack of accelerated test means or predictions that can be correlated to the actual matrix experienced by the equipment. This absence of adequate means for determining in a reasonable period the expected reliability degradation over extended, varying environment periods makes the demonstration of reliability degradation during storage contractually undesirable. Actual experience at a later date becomes the first real indicator of any reliability degradation.

It appears that further research is required on accelerated reliability testing and prediction techniques as they effect reliability over extended storage periods.

Recommendations

It is recommended:

1. That the services conduct studies on systems and equipments to determine the causes and degrees of reliability degradations in storage so that programs can be developed to minimize degradation.

2. That research be supported to investigate accelerated testing techniques for predicting and measuring reliability degradation in storage.

INCENTIVES TO MINIMIZE ADVERSE RELIABILITY AND QUALITY TRADE-OFFS

Incentives to minimize adverse trade-offs which affect product quality and reliability are not being fully exploited.

The use of Cost-Plus-Incentive-Fee type contracts increased measurably from FY 1954 through FY 1964. The present trend is towards greater use of multiple incentive contracts with particular emphasis on performance parameters. The usage of performance incentive contracts increased more than five fold during the period FY 1962-FY 1964[1].

Properly structured multiple-incentive contracts should motivate the contractor to strive for outstanding results in all three incentive areas, i. e., cost, schedule, and performance. The contract should be structured so that the contractor can by achieving the desired performance specified by the customer maximize profits in all these areas and permit his management decisions to be in the best interest of both the government and the contractor.

The best means to insure that trade-offs that adversely affect reliability are minimized is to make certain the reliability and quality are consideration in the first place. If reliability and quality are not on the shopping list of prime considerations initially, then it goes without saying that their chances of weighted consideration will be minimal at the time of actual trade-offs.

The structuring of multiple performance incentives, along with time and cost considerations, is a recognized, difficult task requiring both project oriented personnel and contract specialists. Not only are there pitfalls in the conflicts generated by different profit levels associated with the three areas, but often the performance incentives require a weighting process between the variable factors themselves. As an example, decreases in weight or materiel are often traded off for increases in speed, with both possibly having decreasing effects on reliability. In some equipments such as surface-to-air missile systems, high system availability is of utmost importance, with a theoretical infinite number of trade-offs possible between reliability and maintainability. This points up the need for some control on an acceptable level of reliability as well as demonstration means to determine quantitative parameters.

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[1]DoD Incentive Contracting Guide 1965, OASD (I&L), pg. 95.

In monotonic fee concept[1], during weapon system development, the objectives are considered to be (1) the achievement of a high level of military effectiveness, and (2) a low life cycle cost (cost for development, production, operations, logistics, maintenance, and training). The effectiveness of incentive contracts should be reflected in the results of contractors' efforts which are motivated by incentive fee and measured in terms of incremental life cycle and weapon system effectiveness. The incentive plan should reward the contractor for lower total costs and higher effectiveness. The basic difference between performance incentives in this monotonic concept and the traditional multiple incentives, such as weight, speed, reliability, thrust, etc., is that in the monotonic concept, the fee paid the contractor is determined by complex functional relationships in a math model as opposed to the total fee being the sum of the fees for each performance parameter in the traditional multiple incentive contract. This results in essentially an incremental effectiveness vs incremental cost relationship for trade-offs. The proponents of this sophisticated incentive structuring consider it superior in that it requires the contractor to make decisions that are favorable to the government in his own quest for incentive fee.

The monotonic concept leaves the contractor with a wide latitude for trade-offs that are relatively mission oriented over the entire life cycle and not just the development phase, but like the multiple incentive contract the performance characteristics must be structured either to priority of achievement or subject to a weighted index in the initial modeling.

In all incentive contracting, the government should be able to specify acceptable minimum quantitative reliability and must be prepared to insist upon a simple contractual agreement that there will be no fee award earned unless all minimum performance characteristics are met. This provision, in the final analysis, is the only assurance that other characteristics are not suboptimized at the expense of reliability and quality. Values above this minimum should be subject to trade-off as variables in the effort to optimize cost, time, and performance.

[1]DoD Incentive Contracting Guide 1965, OASD (I&L), pg. 102.

Recommendations

It is recommended:

1. That incentives be designed to minimize adverse trade-offs which affect quality and reliability.

2. That reliability and quality incentives be structured into contracts where possible.

PARTS FOR HIGH RELIABILITY/LONG LIFE APPLICATIONS

Mechanical, electrical, and electronic parts (including microcircuits) of unknown reliability are approved for use by designers of equipments for systems requiring high reliability or long life.

The inherent reliability and longevity of many military and federal standard parts are quite variable and generally not known. These parts are usually contractually required. Established reliability (ER) parts specifications exist for twenty-two high usage electronic part types whose level of reliability is specified and known to be high. Since ER parts are not generally contractually required, they are infrequently used in current new design, resulting in high cost and long delivery. Contractually specifying ER parts in development contracts would ultimately increase their availability, lower costs, shorten delivery times, upgrade the life characteristics of the parts themselves, and reduce maintenance costs.

Weapon and space systems are rapidly increasing in complexity; reliability and long life requirements are concurrently becoming more stringent. More stringent reliability and quality assurance requirements have helped to increase the reliability of many systems. Marked improvements in system reliability have been achieved in systems, such as Polaris and Minuteman, using ER parts of 100% screened parts whose life characteristics have also been controlled.

Recommendations

It is recommended:

1. That development contracts specify, to the maximum extent possible, the use of available ER grades of parts in all critical subsystems consistent with their requirements.

2. That 100% acceptance screening, including burn-in where applicable, should be required for all electronic parts not covered by ER specifications and used in critical subsystems. Provisions should be made to accumulate and disseminate the data generated from these tests.

3. That the ER parts specification programs be expanded to other electrical and electronic parts, including microcircuits. Also, high usage mechanical parts should be studied to determine the feasibility of ER specifications for them.

4. That DoD and NASA investigate the methods of qualifying microcircuits based on commonality between different types of circuits.

5. That DoD determine the feasibility of screening procedures for mechanical parts, similar to those for electronic parts.

6. That DoD determine the feasibility of expanding the use of ER parts in other than critical subsystems in order to attain economic production runs and to insure availability.

7. That preparation of the proposed DoD/NASA Handbook of Parts Screening and Burn-in Procedures (for electronic parts) be accelerated.

TIME PHASING OF RELIABILITY AND QUALITY ASSURANCE FUNCTIONS IN THE PROGRAM CYCLE

Reliability and quality assurance functions are frequently initiated too late in the program cycle resulting in necessary functions being omitted, particularly in the development phase. As a consequence, probability of mission success, reliability assurance and cost-effectiveness are all reduced.

Phased planning and phased program control have been initiated for large development projects by DoD Directive 3200.9. If established DoD decision points were related to specific reliability and quality assurance functions necessary to optimize system effectiveness, proper timing of necessary functions would be greatly enhanced. Also, such an effort would facilitate definition and validation of reliability and quality assurance functions for fee determination on incentive contracts, which are frequently employed in later phases.

Army Missile Command Regulation 702-1 requires a Product Assurance Plan describing work elements, their time phasing and responsibility for each new missile system. Minimum requirements for each element and typical relationships are shown. A similar effort is underway in two documents being prepared by Air Force Systems Command.

One document (AFSCM 80-X, coordination draft dated January 1966) relates reliability programs and functions to pertinent phases; the other, in rough draft stage, (presently titled System Program Office/Program Office Procurement Quality Assurance - AFSCM 74-X) contains quality assurance functions and reliability test requirement procedures.

The complementary nature of reliability and quality assurance functions should be exploited when identifying the generic steps necessary at each phase. For example, criticality of hardware and of specific modes of operation determined during the development phase by a failure mode, effects and criticality analysis are useful in identifying critical tests and specific characteristics to be verified in subsequent test, inspection and operational checkout. Criticality determinations are also used in assessing failures and malfunctions, evaluating corrective action and determining controls and other actions necessary to prevent repetition. NASA NPC 200-1A requires government QA representatives to consider such analyses (and other reliability data) in selecting mandatory characteristics for government agency inspection. However, unless these analyses are executed during the proper phase, they are not available in time for such use.

Recommendations

It is recommended:

1. That the services develop appropriate guidelines which permit relating specific reliability and quality assurance functions to each program phase.

2. That the services should place more emphasis on making reliability and quality assurance functions complementary to ensure completeness, timeliness and cost effectiveness. Policies, procedures and related procurement regulations, should reflect the value of complementary reliability and quality assurance efforts.

SPECIFICATIONS AND SPECIFICATION GUIDELINES

Specifications and specification preparation guidelines for supply procurement are inadequate in many instances.

The adequacy of specifications used for military procurement has been the target not only of the Congress and GAO but also the Department of Defense. In considering the adequacy of specifications, two specific areas must be considered:

1. Specifications covering newly developed items to be introduced into the supply system.

2. Specifications covering items already in the supply system.

The adequacy of a specification relating to 1. above is dependent upon:

1. How precisely the requirements and design constraints delineated by the SOR are quantified during the prototype production and test and evaluation phase; and

2. How realistically can the quality and reliability parameters indicated by service tests be extrapolated to those attainable in supply quantity production.

The adequacy of a specification relating to 2. above is dependent principally upon the effectiveness of a system for updating these specifications in relation to changes in the state-of-the-art and the availability of technical data relating thereto.

It is an established fact that a sufficient amount of production engineering and service testing can not be accomplished on a vast number of end items or components during the RDT&E phase to insure that the final specification is adequate for competitive supply procurement because:

1. The RDT&E contractor is generally selected on the basis of superior technical competence and ability to perform. Accordingly, he is not necessarily representative of the industry which normally become the suppliers.

2. The prototype and service test quantities involved in RDT&E do not represent production runs. This limits the amount of production engineering that can be accomplished. Furthermore, because the prototype and service test quantities are generally "engineering models,"

tests may lead to the establishment of quality and reliability levels that cannot be attained in supply procurement other than through sole or limited source procurements or at a high cost or both.

RDT&E activities within the military departments are fully aware of the foregoing and accordingly, some have taken steps to insure that all aspects of the specification are reviewed by competent personnel during the engineering development and test phase prior to recording the requirements and design constraints and quality and reliability levels in a final specifications for procurement purposes.

A technique proven successful to ensure adequate specifications for procuring a new item involves production testing of the developers proposed specification prior to supply procurement.

Basically, the technique involves awarding a minimum production run of the item to a representative segment of the industry. Inadequacies and misunderstandings are resolved at the plant level.

Following the production test, the proposed specification is revised to include all authorized changes. The final specification highlights the operational requirement trade-offs that must be made and accepted for competitive procurement.

The DoD Technical Logistics Data and Information Committee constituted a subcommittee in July of 1963 to assess the functions and proper content of military specifications. The scope of the subcommittee's study was:

1. To evaluate the functions served by specifications and their proper management to serve the needs of DoD and industry most effectively.

2. Analyze the content of the total range of documentation employed for the acquisition or purchase of system, subsystems, equipment, parts, material and services according to purpose and dollar value.

3. Recommend policy and conceptual changes relative to problems evident from the above evaluation and analysis.

The final report contains recommendations which should materially improve specification guidelines when fully implemented.

Recommendation

It is recommended that the services explore the feasibility of expanding the use of specification production testing techniques.

RESOURCES FOR ADVANCING RELIABILITY AND QUALITY TECHNOLOGY, RELIABILITY AND QUALITY PROGRAMS, AND RELIABILITY DEMONSTRATION

The first resource requirement concerns research and investigations to advance R&Q technologies. This will improve our ability to provide more accurate predictions, demonstrate reliability and measure quality with a minimum expenditure of time and money. Laboratory pioneering is required to improve the capability of making reliability evaluations with the desired level of confidence in the allotted lead time in the RDT&E time cycle.

Such evaluations would enable logistics people to optimize their operations, and to know how long the fielded equipment will operate under the rigors of military usage. The end result would be improved cost effectiveness.

In spite of these well-known considerations, resources are inadequate for these much-needed research and study procedures. DoD requirements and implementing directives can only be effective when supported with adequate resources to ensure realization of the required reliability and quality in development programs. The root of the problem is the emphasis of budget managers upon commodity oriented programs aimed at the acquisition of hardware. As a result, studies for the advancement of a technology such as reliability have suffered.

The second requirement is the application of R&Q programs to the development of military equipment, and the demonstration of the effectiveness of such application. Timely identification of R&Q functions (see page 76) is only the first step in establishing adequate R&Q programs. Once established at the proper time in the program cycle, adequate resources in dollars and competent manpower must be provided.

Resources or money and manpower for both areas are seriously inadequate in many instances.

Recommendation

It is recommended that the OSD provide the necessary resources in manpower and funding to expand efforts for the advancement of reliability and quality technologies, and ensure that each project identifies adequate resources for the R&Q program and its proper demonstration.

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REPORT OF PANEL 3

TITLE: Quality and Reliability Assurance in the Production Phase

OBJECTIVE:

To improve the capability within the DoD to establish requirements for and to obtain materiel possessing the necessary quality and reliability during the production phase.

TOPICS DISCUSSED:

1. Adequacy and Completeness of Technical Documentation used for Materiel Procurement Purposes
2. The use of Systems Specifications MIL-Q-9858 MIL-I-45208 and MIL-C-45662
3. Cost Considerations in Production Quality Assurance
4. DoD Quality and Reliability Assurance Technical Procedure
5. Utilization of Customer Deficiency Reports to Improve Product Quality
6. The Quality Assurance Role in Overall Contractor Performance Evaluation
7. Role of Incentives and Warranties in Improving Quality
8. The Role of Government Quality Assurance in Subcontracts
9. Contractor Quality Control Versus Government Quality Assurance
10. The Impact of Procuring Activity Product Evaluation on Administering Agencies
11. Adequacy of Government Control Over Nonconforming Supplies
12. Quality Assurance Response to Fluctuating Workloads

13. Quality Requirements and Activity for Small Dollar Procurements

14. Procurement Quality Assurance Interface Problems

PARTICIPANTS

Chairman	Captain F. G. Scarborough, USN, HQS DCAS
Panelists	Lt.Col. Albert B. Chealander, USAF, AFCMD, Los Angeles
	Mr. Robert McKay, HQS, AFLC
	Mr. Al Garland, Naval Shipyard, San Francisco
	Mr. Edward L. Johnston, NAVWEPS Quality Assurance Office
	Mr. E. D. Johnson, DCASR, St. Louis
	Mr. Rene L. LaBonte, Defense Personnel Support Center
	Mr. Morris K. Dyer, MSFC, NASA
	Mr. John J Obren, Army Munitions Command
	Mr. Richard Tiner, HQS, AMC
	Mr. Martin B. Broude, FSS, GSA
Recorder	Mr. J. W. Comish, HQS, DCAS
Monitor	Mr. John J. Riordan, OASD (I&L)

ADEQUACY AND COMPLETENESS OF TECHNICAL DOCUMENTATION USED FOR MATERIEL PROCUREMENT PURPOSES

Top management of both industry and government have repeatedly stressed the necessity for improving the technical effectiveness, criteria and application of technical documentation incorporated into procurement packages. The prime objective of this stress has been to reduce procurement costs, increase competitive procurement, eliminate goldplating (thereby achieving cost reduction) and capitalize on the "state-of-the-art" improvements. Since prior observations and recommendations have normally been extremely general in nature, it has been difficult to measure the degree of improvement that government agencies have achieved.

Improvement in this area cannot be measured separately but must be evaluated as part of the whole system, i. e., final product quality and performance is largely dependent not only on the technical documentation itself, but also, the management, control, etc., exercised by the producer and the government contract administration practices. However, improvement in this area could contribute significantly towards achieving the prime objective.

Although industry has at times been extremely critical of the inadequacy and incompleteness of technical documentation, they have simultaneously been critical of technical documentation being too detailed, thereby eliminating the application of their engineering and manufacturing knowhow to reduce costs. From an overall government viewpoint, it would appear that the objective lies closer to the detail approach with provisions to capitalize on cost reduction aspects through such media as the value engineering incentive clause in following competitive contracts.

Within the present technical documentation acquisition structure, three prime techniques are in effect:

1. Technical documentation is generated completely within a government in-house engineering center, with or without contract technical service support, i. e., drafting services, editorial services, etc.

2. Technical documentation is generated by both a contractor and a government in-house engineering center, as an initial joint venture.

3. Technical documentation is generated completely by a contractor. From a utopian government viewpoint, the first cited technique is the most desirable. However, from a practical and realistic viewpoint, the government will be faced with the data acquisition techniques cited above, including some variations thereof, and the problems associated therewith to insure technical documentation adequacy.

Accordingly, the government effort to assure technical documentation adequacy must consider the following:

1. Administrative Review

Compliance with established format requirements (MIL STD-100, MIL-STD-1000, MIL-STDs-1 thru 31, etc.).

2. Design Review

Technical adequacy of the design disclosure technical documentation.

While the inadequacies in data such as restrictive legends or missing drawings, specifications, etc. are frequently found in assembling a procurement package, inadequate QA provisions are less often detected. The pressure to compete to the maximum has increased problems in this area since the first sign of inadequate QA provisions frequently comes to light when defective product is found in the system. Specifications which may have been satisfactory when used with sole source producers many times become highly inadequate when used with a new source.

One way of countering some of these problems is to assure that quality engineering type personnel participate in the development of technical documentation and then later give all procurement packages a final thorough QA review prior to the initiation of a procurement action. While quality specialists are not a panacea for all problems, the questioning mind of persons who have lived with, and attempted to accept product based on specification requirements frequently raises questions which have gone unnoticed in engineering assessments.

Since the government deals with a multitude of contractors, one of the problems it is faced with is that of communications, i.e., to be able to convey to the technical contractor staff through written media (notes on a drawing, the interpretation of words in a specification, the meaning of quality assurance contract clauses, etc.) the total requirements of an item. This is not meant to infer that these technical staffs do not possess the capability but rather that these staffs must go through a "learning curve" due to changes in the staff brought about by resignations,

retirement, etc. Accordingly, improved communications could be generated by centralizing within the quality assurance organization of the following functions:

1. Providing quality assurance contract clause input to the contracting officers.

2. Arranging for the conduct of post award type conferences, when required (new producers, etc.), to assure that the contractor has a thorough understanding of the product quality requirements.

Trends to depend more and more on contractor knowledge and less on Government in-house capability to test and evaluate certainly must be considered as contributing to some of the poor quality procurement packages which find their way into contracts.

Recommendations

It is recommended:

1. Short Range - That OSD issue policies which provide for a requirement that quality assurance personnel:

a. Review the technical documentation for adequacy prior to a procurement action.

b. Provide the required quality assurance contract clause input.

c. On major procurement contracts arrange for the conduct of a post award type conference to assure a sound understanding of the product quality requirements.

2. Long Range

a. That all elements of DoD continue to stress the necessity for sound "Configuration Management" practices including adequate testing and evaluation of both the materiel and technical documentation.

b. That OSD establish a DoD Committee to determine what additional quality assurance contract clauses would be beneficial for inclusion in ASPR.

c. That all elements of DoD continue to stress the necessity for quality assurance engineering personnel participating in the development of technical documentation.

THE USE OF SYSTEMS SPECIFICATIONS MIL-Q-9858 MIL-I-45208 AND MIL-C-45662

There is a lack of definitive criteria for the selection and inclusion into contracts of systems specifications. Correspondingly, there is a lack of complete guidance for the equitable evaluation of implemented specifications between contractors. Compounding this problem is a move by some industry associations to introduce supplemented systems specifications which will fractionate the standardized approach achieved in MIL-Q-9858, MIL-I-45208 and MIL-C-45662.

Prior to the issuance of the "A" revision to MIL-Q-9858 there were several system specifications, in the quality area, being imposed by contracts on defense suppliers. The scope and depth of coverage varied depending upon the military service/purchasing office that developed and invoked the specification. This resulted in confusion among contractors who did business with more than one service and among contract administration offices who may have received contracts from purchasing offices outside their command by interchange.

Compounding the problem of multiple, service-oriented, systems specifications was the problem of evaluation criteria of contractor implemented systems. Greater confusion existed in this area in that there was as much difference in evaluation criteria used within the services as there was between the services.

Publication of MIL-Q-9858A, MIL-I-45208A, and MIL-C-45662A achieved a degree of uniformity, by self-designation, as only authorized specifications on the subjects covered. The military services then took the necessary steps to rescind their own publications. Guidance of the methods of evaluating these programs was published at a much later date and in the case of MIL-I-45208A it has not been published to date. Therefore, standardization was achieved through the systems specification, but evaluation was and has remained varied.

Presently there is broad policy guidance on some of the problem areas. For example, Section XIV of ASPR contains limited guidance on the application of MIL-Q-9858 and MIL-I-45208. This guidance is not specific nor does it provide definitive criteria for the selection and application of these specifications. In fact, there is a wide variation in the use of these specifications by the various DoD procuring activities. Some activities apply MIL-Q-9858 to virtually all of their contracts, while others use it only on complex major end item or cost type contracts.

The same variation is prevalent in the application of MIL-I-45208. Most of the DoD procuring activities appear to have inadequate knowledge of these system type specifications.

Further, there is insufficient guidance on the actions that should be taken when there is evidence of a supplier's noncompliance with system specification requirements. This particular problem is further compounded when the product offered to the Government for acceptance meets the product contractual requirements. Furthermore, acceptance of nonconforming materiel by waiver, due to the urgency of delivery requirements, dilutes the QAR's effectiveness.

The metal producing industries (steel, aluminum, copper and nickel) have developed a proposed quality program specification specifically designed for metal mill products. This draft has been presented to OSD for approval. OSD advised the metal producing industries that a new specification would not be acceptable but that a redrafting of MIL-Q-9858A with a "slash 1" would probably be acceptable. This type of fractionization of the basic quality program specification completely defeats the purpose of "one specification for a quality program." In addition, publication of such a product-oriented specification would open "Pandora's Box" to any number of "special" quality specifications.

These problem topics are directed to the absence of definitive policy guidance and the nonuniformity of the selection and application of system type specifications by the DoD procuring activities. This lack of uniformity could result in a wide variation in costs incurred by the Government for like materiel procured under the different types of systems specifications. Further, the nonuniformity in selection and enforcement of these specifications affects a supplier's ability to be truly competitive in his bidding.

Recommendations

It is recommended:

1. That OSD develop definitive criteria as to where and under what circumstances each system specification should be imposed by contract.

2. That OSD develop and publish uniform and definitive guidance for evaluating the effectiveness of a supplier's implemented program simultaneously with issuance of the specifications. This guidance must

also include remedial actions to be taken when a contractor fails to meet the system requirements of the specifications.

3. That OSD direct that no supplemental specifications are to be issued to the three existing system specifications.

COST CONSIDERATIONS IN PRODUCTION QUALITY ASSURANCE

The effect on costs of imposing fewer or additional quality requirements, both on the part of the contractor as well as the Government, has not had the same level of attention as provided to other procurement aspects such as performance requirements and delivery schedules. The percentage of procurement costs associated with quality is influenced by several factors, among which are complexity of the product, state of the art, policies of the procuring offices and the policies of the contractors. It is generally conceded that these costs can represent several percent of the total procurement. The lack of quality cost information concerning Government and contractor operations constitutes a void with management process.

Some considerable work has been accomplished by individual contractors, Departments and professional societies, as well as universities in studying the costs associated with quality. Various systems have been developed that would enable management in a given situation to track and control quality costs at a reasonably optimum level. Some of these systems are very comprehensive and involve appreciable changes in accounting systems in order to produce the required information.

With the revision of MIL-Q-9858 in December 1963, a requirement was introduced calling for contractors to maintain and use quality cost data as a management element of the quality program. The specific quality cost data to be maintained and used is determined by the contractor. Since the issuance of this requirement there has been little policy guidance issued by the OASD (I&L) on the subject. The absence of guidance setting forth a definition of these costs and the intended use thereof by both the contractor and government has contributed to a general lack of enforcement of the requirement. In some cases where contractors have developed cost information, there exists a question as to the usefulness of the data.

A few cases have been reported where contractor's quality cost has been separately identified in cost proposals in advance of contract award. This is an area that should be thoroughly evaluated as to desirability, and if it is determined to be desirable, a uniform definition as to what these costs consists of should be developed and issued so as to assure consistency in evaluation of contractors.

Different procedures have been employed by the Departments and DSA in charging contractors for the government costs associated with reinspections. This would be those reinspections required as the result

of government rejection of tendered materiel. Differences in policy also exists for the obtainment of consideration from a contractor in connection with the acceptance of nonconforming materiels. Both of these areas should be thoroughly evaluated to determine the desirability of adopting a single policy to be employed.

Recommendations

It is recommended:

1. That the OASD (I&L) sponsor a study group to explore all facets of production quality costs of the contractor and government. Based upon this study, identify those elements of costs that should be identified and maintained by contractors and the Government.

2. That the study group develop a uniform policy relative to charging contractors for the Government costs associated with reinspections of rejected materiel. A policy should also be developed providing for uniform application of costs considerations in connection with the acceptance of nonconforming materiel.

DoD QUALITY AND RELIABILITY ASSURANCE TECHNICAL PROCEDURE

The dynamic world we live in today, which presents new challenges to weapon system developers in the form of availability of new materiels and of rapidly changing production techniques, dictates that our quality and reliability assurance programs likewise be dynamic. However, with few exceptions, little new in the way of policy or procedure has been issued by OSD in this area in the past several years. There are areas such as metrology and calibration which are not covered by an OSD policy other than guidance on contractor requirements (in Specification MIL-C-45662A, dated February 1962, and in DoD Handbook H-52). There is a real need that a DoD Instruction be issued outlining quality assurance policy on metrology, calibration, and inspection equipment.

Further, most of the existing OSD policies and procedures on procurement quality assurance have not kept pace with the rapid changes being made by other elements of OSD in the procurement function. For example, DoD Handbook H-109, "Statistical Procedures for Determining Validity of Suppliers' Attributes Inspection," is based on MIL-STD-105, but MIL-STD-105 has been revised four times since H-109 was published. Handbook H-109, if updated, would be a useful tool for the uniform evaluation of a contractor's quality records; and could provide a good measure to be included in development of quality criteria for contractor performance evaluation. Similarly, MIL-STD-109, "Quality Assurance Terms and Definition," has not been updated to reflect the latest concepts of government or suppliers' quality responsibilities.

The "H" series of DoD Inspection and Quality Control Handbooks carry the designation "Interim" which fosters the impression that they lack permanency. These should be updated and published as official documents. A further problem exists in that the "H" series documents are not available through normal distribution channels since they are not official documents from the standardization standpoint.

There exists a real and urgent need for updating and taking a hard look at our present procurement quality assurance concepts, policies, and procedures to assure that: (1) they are mutually compatible; (2) they are complete with respect to all required and useful government procurement quality assurance actions; (3) they provide definitive guidance as to contractor responsibility versus the government agencies' responsibility; and (4) effective means are established to keep them current.

Recommendation

It is recommended that OSD establish an effective mechanism to assure that a single series of quality and reliability assurance policies and procedures is officially published, and is kept up-to-date to continually reflect the latest technological advances.

UTILIZATION OF CUSTOMER DEFICIENCY REPORTS TO IMPROVE PRODUCT QUALITY

Based on government reports and resultant articles which have recently made headline reading in the newspapers and other publications, there is a definite indication that poor quality materiel is entering the Government supply system. This poor quality materiel can be basically divided into two categories namely, (1) materiel which has been fabricated in accordance with the technical documentation specified within the contract and is found in actual usage not to meet customer requirements and (2) materiel that has been accepted by the Government, which does not meet established technical requirements specified within the contract. In either situation, expeditious receipt, processing and evaluation of customer deficiency reports could lead to improvement in the quality of materiel being fabricated.

Although the expeditious reporting of deficient materiel by the customer can definitely be of extreme value, the immediate application to production is governed by the following factors:

1. The materiel is still in production and the product deficiency is due to the lack of quality control on the part of the producer and quality assurance practices on the part of the government.

2. The materiel is still in production and the deficiency is one of design. Design deficiencies can be categorized as:

   a. A deficiency that can be immediately corrected via the application of mandatory engineering change.

   b. A deficiency that is of a magnitude that requires extensive engineering effort to correct the deficiency.

3. The materiel is presently out of production, but future buys are contemplated.

Based on the factors cited above, it can be seen that customer deficiency reports can definitely be an asset to improving product quality providing that management systems are established for the expeditious flow and application of corrective actions.

The value of user data in improving product quality depends on timeliness of receipt of information and the ability to relate reported deficiencies to conditions in production. Conditions creating late receipt of information from the field are not always controllable due to supply distribution systems and actions at receiving stations which have higher

priority. Inadequate reports probably will never be completely resolved but any actions that will encourage better, more accurate participation of using activities should be tried.

Another area for further exploration is DoD wide guidance on actions to be taken on receipt of this type information. Failure to reply to field information or sterotyped answers tend to discourage field participation. Emphasis should be placed on the fact that deficiency information is primarily input data for communication between government activities. This is not intended to preclude submission of deficiency information to the contractor but to place the focal point for assuring proper corrective action with government activities rather than the contractor. More and closer government involvement in the actual investigation to correct the deficiency would be more helpful than just limiting participation of the government activity to that of a referral agency.

It is not necessary nor desirable that one standard form be developed within the military services for user deficiency reports, i.e., reports from the field-users of the equipment. The type of information desired and/or reported varies with the type of equipment. However, the existing complaint type forms (AMC 1229, AFTO 109, AFTO 29, NAVWEPS 13070/5, etc.) which essentially deal with materiel not meeting specified contract requirements and represent transmittal information between government agencies, indicate a fruitful area for form and procedure standardization. The information required to perform an adequate investigation on a production line is similar regardless of the buying or using agency involved. As a minimum, action along this line would reduce problems for CAS components who are now confronted with a multitude of forms all of which are intended to perform a like function.

Recommendations

It is recommended:

1. That OSD establish a project for the development of a standard DD Form and appropriate procedures, which can be used as a transmittal sheet for submitting deficiency reports to CAS components.

2. That all elements of DoD review their present deficiency reporting systems to assure that they provide for an expeditious flow of deficiency reports thru quality assurance channels to either design agencies (design deficiencies) or contract administration activities (quality deficiencies), as appropriate.

THE QUALITY ASSURANCE ROLE IN OVERALL CONTRACTOR PERFORMANCE EVALUATION

Since the President's Committee on Government Contracting for Research and Development recommended an exchange of contractor evaluation data among government agencies in 1962, and since the issuance of ASPR 1-902 and 1-903 covering minimum standards for responsible prospective bidders, considerable work toward development of an effective Contractor Performance Evaluation (CPE) Program has taken place within OASD (I&L). In addition to the overall work directed by OSD, CPE programs of various types have been developed and implemented by the Military Departments and DSA.

The primary evaluation factors on all of these programs are cost and schedule. The quality aspects of contractor performance are mentioned in the ASPR references above; however, they are usually considered to be a part of contractor "technical performance." Possibly as a result of the lack of specific emphasis as a separate CPE rating factor, the quality area has not been adequately defined nor has its relative importance to other evaluation factors been determined.

The lack of specific identification and recognition of quality as a key element in CPE is having a detrimental effect on product quality and reliability, and therefore, mission capability. The detrimental effect is brought about by the contractor applying effort to perform best in those key areas which are specifically evaluated (i. e., cost, schedule). The magnitude of the problem will become more apparent as the overall CPE program is more fully implemented, unless steps are immediately taken to strengthen the quality area.

An essential part of effective and meaningful CPE is data generated by plant level quality assurance personnel during day-to-day operations. In order for full use to be made of such data in overall CPE with the least amount of difficulty, it must be generated through a DoD-wide quality assurance program employing common procedures and common terms. At present, several different quality assurance programs are utilized by DoD elements which employ different data collection and reporting methods.

The fact that numerous departmental CPE programs are in use which employ different procedures, complicates implementation of an overall DoD CPE program. Development work is still going on in each of these programs, with some further along than others, however each has strong points which should be considered for use in the overall

program. These programs have resulted in the generation of a considerable amount of data, but due to limited departmental application, these data are not available to all procuring and administration activities that could make use of them.

The Panel is aware of the CPE Pilot Program which is being effected in the supply and equipment area by DSA at the request of OASD (I&L). It is recognized that an essential element of an effective CPE Program is simplicity, and that the evaluation factors contained on the DSA Form 352-A (TEST) Contract Performance Evaluations, have been kept to a minimum. It is considered however, that further study of these factors should be undertaken at the earliest possible time in order to determine if refinements are required.

Recommendations

It is recommended:

1. That OSD establish a task group composed of quality assurance personnel to evaluate the contract administration quality assurance programs now carried out by the several DoD elements and develop a DoD-wide program for implementation at the earliest practicable date. Procedures and resultant data recording and reporting methods developed should be compatible with CPE program needs.

2. That OSD establish a task group of quality assurance personnel to develop specific quality assurance factors for inclusion in the DoD CPE program. This group should consider all factors which have been developed for departmental CPE programs and those used in the DSA pilot program. Suggestions should be solicited from industry. Factors developed should encompass evaluation of quality program elements as well as product characteristics.

3. That OSD establish uniform quality considerations for the DoD-wide CPE program which includes the best features of departmental CPE programs. This program should consider automation so that immediate response can be made to queries for quality and reliability information by any procuring or administering office during preaward and subsequent contract phases. This program should be adaptable to individual contracts as well as individual contractors, and encompass as many contractors as possible. The cost of operation versus value received must be carefully analyzed in developing the program scope and operational methods.

ROLE OF INCENTIVES AND WARRANTIES IN IMPROVING QUALITY

DoD has provided for the use of contractual incentives in ASPR, Part 4, Types of Contracts and ASPR, Part 17, Value Engineering. This guidance has been supplemented by numerous Defense Procurement Circulars. In addition to the above, noncontractual incentives have been employed by procurement activities. These generally take the form of public recognition of superior performance by individual programs through such media as the awarding of flags, plaques, and certificates of achievement. DoD has provided a third type of incentive in ASPR 1-324, contractual warranties.

1. Contractual Incentives

Contractual incentives, as provided for in ASPR, are extremely broad in scope. Practically any aspect of performance may be placed under incentive provisions. These provisions permit monetary returns to the contractor for achievement of stated goals. The goals are usually expressed in terms of cost reduction, scheduled delivery and performance of the item or service.

"Performance" in this sense means mission accomplishment; i. e., whether or not the end item functions. This preoccupation with the end item masks the fact that there should be methods of measuring progress toward the achievement of the quality goal during the production phase. The reason for this consideration is that quality and reliability evaluation elements have not been well defined in incentive contracts. A penalty levied on the contractor after failure to meet a performance goal is like closing the barn door after the horse is stolen. Quality and reliability incentives should be extended into the production phase. Failure to do so up to this time is possibly due to the difficulty of defining such factors.

Apart from performance incentives as applied to the area of major systems and weapons, there are other areas in which performance incentives may be utilized to improve quality. For example, if there exists definitive requirements for an item including acceptable quality levels (AQL's) should extra payment be made for delivery of product better than the AQL? Generally speaking, it is not believed that this is a suitable are for incentive payments. The AQL or other standard of performance imposed by the contract should be set at that point which will provide a sufficiently broad base for procurement of a competitive nature and yet meet the needs of the user. Thus, a contractual incentive payment for better quality might tend to restrict competitive procurement

and go against the principle that standards should not be set higher than required. Nevertheless, it is recognized that for a high unit volume procurement of a given item a small increase in the quality of product will on the average provide a larger number of useable units with a longer serviceability or appearance life. For example, a procurement for 100,000 hydraulic fittings permits delivery of 4% defective product. If the actual delivery is no more than 2% defective, obviously there are 2,000 more units that can be used. This situation must take into consideration a contrary factor, namely a fact that small increments in quality improvement could become disproportionately costly. This brings us back to the proposition that the AQL or other standard of performance imposed by the contract is probably the best compromise between minimum needs and broadly based competition.

Value Engineering Incentives are designed to reward contractors who suggest changes in design, manufacturing processes, or use of newly designed or other substitute components which lower the cost without downgrading quality or performance of the end item. Since a VE change may improve performance at lower cost, value engineering incentives may be considered under the general topic of incentives as a means of improving quality.

2. <u>Noncontractual Incentives</u>

Noncontractual incentives, such as the awarding of flags, plaques, or certificates of achievement, recognize superior performance or, at least, recognize consistently good performance and timely delivery arising out of a well-organized management effort. They are particularly suitable for use in competitive procurements of high unit volume with definitive specification requirements where, as stated above, incentive payments for delivery of quality better than required by the contract are inadvisable. Noncontractual incentives are designed to promote improved management and use of quality programs that will better assure delivery of conforming product on schedule.

Such incentives are based on the principle that people will strive for recognition of achievement even though there may be no direct monetary reward involved. The achievements of the Zero Defects program, as adopted by thousands of major manufacturers, attest to this. Quality recognition programs are a significant factor in assuring delivery of conforming supplies on schedule.

3. <u>Warranties</u>

Contractual warranties, which provide that the contractor warrants the quality of product at time of delivery to conform to contractual standards, are an indirect means of improving quality in that

they provide penalties for nonconformance. They may be considered as incentives in reverse.

When the Government exercises its rights under warranty provisions of the contract, it recognizes the existence of a failure in the contractor's quality program as well as in the Government's quality assurance program. The Government's loss usually cannot be fully regained by any action it takes under the warranty article primarily because it has been denied the use of acceptable product during the interval from date of original delivery of nonconforming product to the data of fruition involving actions of replacement, repair or recovery of monetary compensation for damages suffered at the time of delivery. If the defective product has been discovered through normal government procurement quality assurance actions prior to acceptance resulting in rejection of product, any delays in delivery of conforming product occasioned by the rejection may be compensated for by an adjustment of contract price in consideration for a possible extension of delivery schedule.

Recommendations

It is recommended:

1. That OSD request the Services and DSA to furnish the results of their experience to date with incentives and warranties, relative to quality and reliability.

2. That OSD identify quality and reliability evaluation elements during production for performance incentive contracts.

3. That OSD assess the overall impact of warranties with emphasis in the considerations of their cost, their relationship to all types of incentives and their appropriate application.

4. That OSD use the data for developing further guidelines for the use of procuring activities.

THE ROLE OF GOVERNMENT QUALITY ASSURANCE IN SUBCONTRACTS

The DoD manages over half of the federal budget; more than fifty billion dollars annually. At the present rate, about thirty billions of that go into subcontracts. Usually major system procurements require the contractor to subcontract some portion of the work. The spread may include the largest "prime" plants at one end and the smallest of shops at the other. Subcontract business is not limited to the small "bucket" covered by the non-resident quality assurance representative.

The lack of subcontractor conformance to quality requirements of critical characteristics in items procured by prime contractors continues to be a serious and costly problem to the government. Many defective components and parts have been installed in major weapon and space systems as a result of this problem. Government attempts at assuring adequate quality control of subcontracted supplies has resulted in imposing large source inspection workloads upon government quality assurance personnel servicing subcontractor plants.

Why Government Source Inspection? The requirements for government inspection are spelled out in the Armed Services Procurement Regulations (ASPR) and are written into government contracts. These inspections are to assure contract compliance and to protect the interests of the government. Stated as an oversimplification, the Government inspects certain selected important characteristics, performs acceptance inspection and accepts those supplies and services that are found satisfactory. Often the individual making acceptance for the Government cannot assure all of the necessary tests and examinations on subcontracted supplies. He therefore may request assistance from the government agency having cognizance over the subcontractor. Requests for such assistance are initiated as statements calling for government source inspection (GSI) on purchase orders and are usually supported by a letter of delegation from the requesting agency.

Government source inspection should not be requested on items which can be adequately inspected upon receipt at the prime contractor's plant. GSI is usually requested on shipments direct from subcontractors to government installations. On noncomplex items, the purchase orders may require certificate acceptance or acceptance at destination.

Government quality assurance at the subcontractor's plant is essentially an extension of government quality assurance at the prime contractor's facility. Some problems encountered by government quality

assurance personnel at subcontractor plants are late receipt of the subcontract or letter requesting GSI, insufficient information in the subcontract or the letter requesting GSI, lack of adequate prime/subcontractor quality assurance, and the large number and variety of plants to be covered on an itinerant basis.

The current policy of "disengagement" insofar as GSI is concerned has many different interpretations. It was obviously designed to discourage GSI and to place the burden where it belongs, on the prime contractor. The prime contractor is solely and exclusively responsible for the quality of all goods and services delivered to the government, whether the goods and services are produced in the contractor's plant or procured from his suppliers.

It is well established that the Government reserves the right to verify contract compliance by performing inspection at selected points in the process including government source inspection under subcontracts. Some government quality assurance activities have eliminated the practice of requesting GSI on prime contractor purchase orders. Others request GSI only for those selected items possessing critical characteristics which cannot be verified upon receipt. Still others continue to request GSI without regard to the complexity or criticality of the subcontracted items. In some instances, prime contractors encourage GSI, with a view toward reducing their control at the subcontractor plant or in their receiving inspection, or a combination of both.

Inspections performed by the Government are essential elements of a verification system and not necessarily a duplication of the contractor's effort. The goal of such a verification system is to take sufficient samples, but only sufficient samples to determine product quality on which to base reasonable, valid decisions for acceptance. The system strives to be both effective and economical. The contractor is paid to control the product, processes and systems. Government source inspection verifies that control was established and product quality maintained.

Recommendation

It is recommended that OSD incorporate the following concepts in policy and procedural directives in order to clearly define the Government quality assurance role in subcontracting:

a. Hold prime contractors completely responsible for the quality of supplies received from their subcontractors and vendors through clear and definitive contractual language, notwithstanding GSI.

b. Require government quality assurance review of prime contractor proposals for subcontracting.

c. Strengthen government review of prime contractor's quality system including written procedures for control over the quality of subcontracted supplies.

d. Define the specific circumstances under which GSI may be applied.

e. Provide that all requests for GSI contain absolute identification of specific products, processes, critical characteristics and other requirements to be examined.

CONTRACTOR QUALITY CONTROL VERSUS GOVERNMENT QUALITY ASSURANCE

Procedures developed and used by the Departments and DSA for the conduct of procurement quality assurance contain some basic conceptual differences. In the product verification area, for example, some of these procedures emphasize the utilization of standard sampling plans, where the sample sizes to be verified by the Government equals or approaches the sample sizes employed by the contractor. Provisions are included for reducing sample sizes and frequency of sampling based upon contractor-demonstrated effectiveness. Other procedures emphasize the measurement of the contractor's effectiveness by the employment of a constant sample size at an established minimum frequency that provides for increasing the amount of Government verification contingent upon the contractor's demonstrated effectiveness. In addition to this constant sample size technique, provisions are made for direct product verification for acceptance purposes which allow for recognition of purchasing office requirements as well as local determination as to necessity.

Variations also exist between the Departments and DSA procedures in the approach to be followed in determining that a contractor is following his prescribed procedures.

These conceptual differences between the Departments and DSA are particularly evident in the product verification area. These variances appear to reflect differences in philosophy as concerns the purpose for conducting product verification. On one side, emphasis is placed on product verification for product acceptance purposes, whereas on the other side product verification is accomplished primarily for the purpose of determining contractor's effectiveness in controlling product quality, which in turn provides the basis for product acceptance.

There is a need for a greater degree of standardization by the Departments and DSA in the procedures to be utilized for determining that a contractor is effecting the required degree of product quality control in accordance with the terms of the contract. It is considered absolutely necessary that the procedures provide recognition of the relative importance of individual procurements and a clear distinction between the activities associated with:

1. Review of contractor's written quality control procedures.

2. Determining on a continuing basis contractor's adherence to his written procedures.

3. Direct government product examination for product acceptance purposes.

4. Evaluation of the accuracy of contractor's decision regarding product quality.

5. Corrective action.

These procedures must take into consideration the basic DoD policy setting forth the contractor's responsibility for controlling product quality and must recognize the economical significance as concerns employment of government quality assurance personnel. It is equally important that these procedures, primarily as they involve product verification, provide for flexible applications at the local level. They should be developed to allow for increased or decreased Government effort commensurate with demonstrated contractor effectiveness.

It is the opinion of the panel that the proposed Appendix Q to the ASPR as presently developed by the ASPR Subcommittee does not fully meet these requirements.

Recommendation

It is recommended that the ASPR Committee assure the development of standardized procurement quality assurance procedures to be employed by the Departments and DSA; that these procedures reflect the basic policies of the DoD concerning the contractor's responsibility for the control of product quality, and recognize their impact on Government quality assurance manpower. Procedures should be adaptable to different products and to allow for increased or decreased government effort commensurate with demonstrated contractor effectiveness. Recognition should be provided to the intrinsic value of individual products to the total military mission. Considering the relative importance of these procedures, they should be adequately service-tested and evaluated prior to full implementation.

THE IMPACT OF PROCURING ACTIVITY PRODUCT EVALUATION ON ADMINISTERING AGENCIES

Basic to good management is an ability to assess efficiency or effectiveness of the operation being managed. The DoD in recognition of this, has imposed upon the departments requirements for evaluation of the quality of material entering or in the inventory (DODI 4155.11). The military departments have all established methods and procedures to control and evaluate the quality of material entering the inventory. The methods used, the extent of coverage, the points in time where the evaluation is made all vary greatly from activity to activity. In many cases the evaluation included detailed involvement in the administration of the contract in the plant. The establishment of the Defense Contract Administration Service and corresponding changes in departmental responsibility under Project 60 created changes of considerable magnitude within all departments. High on the list of changes in many activities was the need to re-evaluate the methods used in assuring quality of product under the new concepts of operation.

Some of the differences in evaluation techniques are due to commodity peculiarities which experience has shown are necessary. Others are due to practices which grew up with the agency and which require considerable personnel reorientation to completely resolve. Every effort is being made to revise and develop internal regulations compatible with departmental responsibility for the quality of materiel and responsibilities of the Contract Administration Services (CAS) for in-plant quality assurance. However, complete reorientation of personnel involved is difficult and has not been accomplished as rapidly as desired. For example, some of these "people" problems between DoD agencies have been brought about by key inspector, commodity specialist or technical representative visits during production and that have unnecessarily been escalated to DoD levels due to misunderstandings. These problems are receiving appropriate attention in the departments and experience has shown that resolution is possible at the operating levels once there is a thorough understanding by all parties of departmental responsibility and approach. The problems that have developed have been primarily due to previous concepts being carried over into a new environment. The panel concludes that there is no significant impact on the administering agency when procuring agency evaluations are properly conducted.

Recommendations

It is recommended:

1. That DoD personnel make every effort to keep interface problems occurring due to procuring agency product evaluations at the operating levels. With proper understanding, "people" problems resulting from Project 60 reorganization difficulties can be resolved without escalation to higher management.

2. That no action be taken by OSD at this time to standardize the procuring activities' approach to product evaluation.

ADEQUACY OF GOVERNMENT CONTROL OVER NONCONFORMING SUPPLIES

Nonconforming supplies, as discussed herein, contain minor departures from the contract, specification, drawing or other applicable requirements as opposed to major departures which require contract change or other equitable consideration. The primary purpose for government participation in the control of nonconforming supplies is to preclude acceptance of any nonconformance that will adversely affect equipment performance, reliability or maintainability. The acceptance of any nonconforming supplies is a privilege extended by the government to avoid unnecessary waste of materials, time, or money.

Some DoD contract administration activities have established Material Review Boards to formalize government control. The Material Review Board generally consists of one government and two contractor personnel with selected skills and specialties that are closely associated with the type of product or processes involved. The right of disapproval is vested in each member since unanimous approval is required for acceptance. Usually, only material accepted by both contractor members is presented to the government member.

Before presenting material to the board, the contractor is required to review nonconformances in detail and assure that material is not presented if it can be reworked or completed to be entirely conforming, or if it is economically unuseable and must be scrapped. Depending upon local option, material that can be used as is, or that can be made functional by application of standard repairs previously approved by the board, may be presented to the board or accepted by the contractor without board action. Thus subsequent acceptance of nonconforming material into the system based on the precedent is established. Criteria established on the basis of precedent acceptance may also be used by the formal Material Review Board in the disposition of nonconforming supplies, this time with concurrence of the government representative. Acceptance based on precedent dilutes requirements for effective corrective action. Adequate corrective action measures are required for presentation to the board when considering the nonconforming material acceptance. Too frequently the corrective action proposed is not adequate or the board fails to monitor the effectiveness of corrective action implementation.

The procedures used by the various DoD components vary in practice and intensity. Some contractors have been required to conform to more than one government MRB procedure. This in effect has produced more

than one quality standard even in the same plant, often for like or similar items being procured. These variations have contributed to an indifferent attitude by many contractors, poor motivation for effective corrective action, and failure to notify local government personnel when items containing nonconforming materials are presented for acceptance.

Some contractors interpret the material review procedure as a method of authorizing raw material substitutions when they should be following Class I change or waiver procedures. When this interpretation is concurred in by government personnel, a proliferation of raw material substitutions may follow. Some of the more obvious results of raw material substitutions are that they:

1. Permit deviations from contract requirements.

2. Ignore the requirement to eliminate the cause.

3. Ignore the requirement for corrective action.

4. Circumvent the established method for processing Class I changes or waivers.

5. Facilitate the use of contractor excess inventory materials.

Although results "1" through "5" above may be undesirable in most applications, there are occasions when it is not economically feasible to revise old drawings, with little future use potential, to replace obsolete materials with currently available items. Result "5" above is frequently most desirable to make maximum use of our national resources and to reduce procurement costs. Typical reasons presented for substitution of raw materials are "unable to procure," "material in stock," or "parts urgently needed in production."

Because of a lack of clearly-defined policy and procedural guidance to control nonconforming supplies of Class II or variation category, the causes for generating nonconforming supplies are not being corrected. Thus, in many instances, nonconforming material is being accepted as a general practice. In addition, time and schedule constraints often encourage acceptance of nonconforming items based on precedents established by previous "use as is" acceptance decisions. In most Government acceptances of nonconforming material, no consideration from the contractor is demanded by the Government.

It is vital that the primary DoD objective for controlling nonconforming supplies include the elimination of the causes of recurring discrepancies and to prevent the occurrence of similar discrepancies.

A DoD panel with quality assurance field representation should be established to prepare policy and procedural guidance for use by all DoD agencies. Such guidance should:

1. State clearly the requirements for contractor control of nonconforming supplies.

2. State clearly the requirements for government control of nonconforming supplies in the contract administration environment.

3. Require effective corrective action as a condition of acceptance for each nonconformance.

4. Limit acceptance of nonconforming items to those in process at the time the original discrepancy is discovered.

5. State clearly that substitution of raw materials and parts shall not adversely affect end item performance, reliability, or interchangeability.

Recommendation

It is recommended that the OSD develop and publish uniform policy and procedural guidance for contractor and government control over nonconforming supplies and materials.

QUALITY ASSURANCE RESPONSE TO FLUCTUATING WORKLOADS

While all procurement management echelons experience problems in responding effectively to fluctuating workloads, the most heavily impacted organizations are those engaged in contract administrative functions, particularly those involved in a geographical operation. The manpower of these organizations is tied to a "level funding" concept, budgeted in advance; whereas, the workload is generated by immediate changes in procurement priorities and quantities.

From a practical standpoint, these organizations have had to project manpower increases and decreases essentially on the basis of the total procurement budget. In a vast majority of cases they are not made aware of new workloads in advance of the pre-award phase. The time lapse between pre-award and award of contract does not allow for justifying additional manpower recruitment and training.

In any sizeable organization involved in a geographical quality assurance activity, it is generally possible to adjust manpower to cover minor increases or decreases in workload. However, these actions are obviously limited.

A significant increase in procurement quality personnel within an organization based upon fluctuating workloads can have an adverse effect on the organization in a declining workload situation. The placement of temporary employees is one solution to the resultant adverse effects of a build up in the organization. However, this route does not eliminate the problems associated with obtaining additional manpower, obtaining necessary budget support, identifying and recruiting qualified personnel and provide for the required training, all in a timely manner.

A possible solution to the problem of immediate response to fluctuating workloads may lie in the CAS organizations being funded for direct labor support from the procurement programs generating the workload requirement. This would permit the manpower authorizations to fluctuate with the workloads.

Civil service procedures involving the hiring of temporary personnel are essentially no different than those required to be followed for the employment of permanent personnel. The mechanism for identifying readily available qualified personnel to be employed on either a permanent or temporary basis should be reviewed to determine what steps could be taken to speed up the process.

Another area that hampers the ability of these organizations to adjust to fluctuating workloads is the amount and apparent inconsistent applications of mandatory inspections directed by the procuring activities. A review of the data contained in Table I concerning the expenditure of directed mandatory inspection by government inspection activities reveals that for the five-month period from December 1965 to April 1966 a 23 percent increase (percentages computed on the basis of total manhours reported) in directed mandatory inspection activity was effected. During the same period of time, there was only a 10 percent increase in the dollar value shipped, and no appreciable change in the total number of quality assurance manhours reported. During this period a concerted effort was made by the government inspection agencies, with some success, to present alternate porposals to purchasing offices recommending reductions in directed mandatory inspection effort. The bulk of this increase in mandatory inspection resulted from the Southeast Asia build up.

Table II shows, based upon April 1966 data, the distribution of directed mandatory inspection by service and the distribution of the total dollar value inspected and shipped by service. These data indicate an inconsitency among the purchasing offices' policies for specifying directed mandatory inspection. For example, 42 percent of the directed mandatory inspection was in support of one Department, whereas only 21 percent of the dollar value inspected and shipped was for the same Department. Thirty percent of the directed mandatory inspection was in support of one agency, which accounted for only 10% of the dollar val shipped. At the other extreme, another Department's procurements accounted for only 6% of directed mandatory inspection and 23% of the dollar value shipped.

The effects of a marked increase in directed mandatory inspection without a commensurate build-up in authorized manpower can only result in a decrease in activity in support of other contracts.

Recommendations

It is recommended:

1. That OSD review and change the present policies and procedures concerned with procurement quality assurance manpower to provide for a capability to respond to workloads.

2. To obtain a reasonable degree of consistency in the expenditure of directed inspection effort between the Departments and DSA, that OSD issue a policy statement setting forth the conditions for the

Departments and DSA to specify directed inspection activity. This policy statement should give cognizance to the relative importance of the materials purchased by the Departments and DSA in comparison to the total military mission of DoD.

3. That DoD policy direction encourage the Departments and DSA to continue existing efforts or to establish definitive programs that would have, as its objective, the minimizing of directed mandatory inspections. Full recognition must be provided to the distinction between individual or types of products as regards their relative importance to the total military mission of the individual Department.

4. That OSD thoroughly explore the practicability of funding the direct labor involved in the CAS field quality assurance effort as an administrative expense of procurements.

Table I. Directed Mandatory Inspection Performed by Government at Source

	Dollar Value Shipped	Directed Mandatory Manhours (M and A)	Mandatory A as % of Total Reported M/H
DEC	$1,142,100,000.00	-------	26%
JAN	1,182,700,000.00	241,416	27%
FEB	1,175,800,000.00	235,836	28%
MAR	1,451,800,000.00	302,622	31%
APR	1,261,800,000.00	284,930	32%
	10% increase from Dec 65 to Apr 66	18% increase from Jan to Apr 66	23% increase from Dec 65 to Apr 66

Table II. Mandatory Inspection Vs. Dollar Value Shipped - by Service

Distribution of Directed Mandatory Inspection by Service (Percent)		Distribution of Total Dollar Value Inspected & Shipped by Service (Percent)
42%	Department 1	21%
12%	Department 2	25%
6%	Department 3	23%
9%	Agency 1	20%
30%	Agency 2	10%
1%	Other	1%

Month of April 1966

QUALITY REQUIREMENTS AND ACTIVITY FOR SMALL DOLLAR PROCUREMENTS

The widely expanded use of the simplified purchase procedures especially in the central procurement area over the past few years have placed these procedures on a new level of importance as a procurement method.

The procedures have gained considerable favor as a means of reducing procurement leadtime as well as procurement costs and fostering competition in the small dollar area. They have proven particularly valuable in an environment where large government stocks maintained at central locations are being replaced by more frequent buys of smaller quantities shipped direct to user. The advantages mentioned have been offset by current ASPR limitations which have created serious problems in the quality area.

ASPR 3-608. 2(b)(1)(ii) covering negotiated procurements of less than $2500 prohibits the use of clauses covering subject matter of any clause set forth in ASPR, other than those set forth in DD Form 1155 and certain specific exceptions approved by ASPR. Several procuring activities interpret this to preclude the use of standard DoD quality or inspection provisions in these procurements many of which require this form of protection.

In addition to a requirement for the option to use the provisions mentioned above, there is an additional requirement for a simple statement of contractor responsibility for inspection of supplies and maintenance of records of the inspections performed. This requirement can be expressed as follows:

1. The contractor is responsible for tendering to the government only those supplies (which term throughout this caluse includes raw materials, parts components, subassemblies and end products and the identification and packaging thereof) which conform to all of the requirements outlined in the purchase order.

2. To fulfill the obligation above, the contractor shall conduct the necessary inspections and tests of the supplies during fabrication and/or prior to shipment, as necessary to provide assurance that the supplies meet the quality standards and other technical requirements of the purchase order.

3. Records of all inspections and tests performed by the contractor on the supplies furnished shall be kept complete and available (to the

Government on request) during the performance of this purchase order and shall be retained 180 days after delivery of supplies. Records shall also include a recording of those checks made by the contractor to assure the accuracy of inspection and testing equipment used to determine the acceptability of supplies for inspection as established by DoD Instruction 4155. 6. The lack of a requirement for contractor maintenance of inspection records seriously impairs the government administering activity from adjusting the amount of government inspection of supplies for acceptance purposes based on reliability of contractor generated evidence. This adjustment of government inspection activity is set forth in DoD Instruction 4155. 6.

The basic ASPR concept that "generally inspection of small purchases shall be at destination" is not fully applicable to this new area of usage since many of the items cannot be inspected at destination and require close control during manufacture. The present concept of ASPR 14-106 on protection for the government on small purchases is primarily aimed at obtaining the replacement of correction of defective supplies. This concept while appropriate as a base procurement philosophy is not completely acceptable under current operations since delivery of defective supplies can create serious problems of non-availability of military equipment. Repair lines, field maintenance or contractor field teams unable to perform scheduled work due to defective supplies creates problems out of all proportion to the dollar value of the contract or cost of inspection which could have been performed at source. Both of these areas should be thoroughly studied by the ASPR Committee for possible revision or clarification. Caution should be exercised to assure that only those procurements meriting source inspection are so identified.

Two forms of Certificate of Conformance (COC) have been in use by several procuring activities for some time in addition to the other forms of inspection and acceptance. One was initiated at the option of the administering agency and used to reduce inspection workload in facilities with good quality history. The other is initiated by the PCO and is used in cases where inspection at source cannot be performed and inspection at destination is impractical. In this case it is used as a form of warranty allowing time for the government to detect any deficiency in the supplies and obtain restitution from the supplier in the event deficiencies are found. It has been used quite extensively when doing business with distributors, wholesalers, etc. Both forms of COC had certain utility and reduced the workload for the administering agencies. This area warrants thorough study to determine if COC is the best way to meet some of the problems the departments have been trying to solve through their use. If so, ASPR should recognize and establish appropriate guidance.

The number of procurements falling into this category continues to increase. One command reports over 86,000 separate central procurement actions under $2500 in one 12-month period. The Defense Contract Administration Service in a recent study found in excess of 50,000 contracts under $2500 assigned for administration. This represented 36% of the contracts on hand. Sixty-six (66) percent of these required inspection at source. CAS considers that this situation absorbs government source inspection manpower that could be better utilized on supplies having higher relative importance to the total military mission.

A service test is currently under way to test the use of the procedures on contracts up to $10,000. If successful and approved for DoD use, this will further increase the use of the procedures. While there is evidence of some abuse of the procedures and a need for policing by the departments, revision of ASPR could greatly improve the situation. If the services are to make maximum use of the advantages inherent in the procedures, better protection and additional guidance must be provided.

Recommendation

It is recommended that an ASPR case be established to investigate the simplified purchase procedures with the objective of allowing maximum use of the advantages inherent in the procedures while maintaining necessary government quality protection.

PROCUREMENT QUALITY ASSURANCE INTERFACE PROBLEMS

At the ASD management level and at the grass root operating level there are actions underway in the quality and reliability areas that indicate that these two elements of DoD are not compatible. This is typified by such programs as systems management, system effectiveness, total procurement package concepts and others which highlight special attention to commodities and management concepts that are in the limelight at a particular point in time. These concepts do not recognize the needs of the long range DoD quality and reliability requirements.

Existing DoD policies and concepts fail to recognize the importance of a total quality and reliability program. More basically they fail to recognize that there are several methods or approaches used in development of a weapon system.

Essentially there are two general approaches followed in the development of defense material:

1. Development is by the government at one of its Engineering Design Centers.

2. Development and production is by American industry.

There are advantages and disadvantages in both of these basic methods. Regardless of the benefits, these approaches are considered to be the two procedures available to the Department of Defense in development of its complex weapons systems.

Those items that are developed in-house, so to speak (by the Government engineering centers), are developed realizing that mass production will be on a competitive procurement basis and definitive drawings, specifications and supporting data will be prepared as the item is developed. Items that are developed by American industry normally go to that industry for at least the first production contract for the item. Thus the technical documentation for these items is not as detailed and complete as those items designed in-house by the Government.

Existing DoD policies fail to recognize the total quality and reliability requirements and the variation in the technical documentation for items developed in-house as opposed to those developed by industry. Essential quality considerations in the development phase are either

missing or have not been coordinated with the production quality assurance personnel. Major decisions affecting quality, made during production, are often not available to the maintenance and operating function. Further, this fragmentation has expanded at the departmental level and has resulted in a wide variation in the methods utilized in determining product quality. There are several DoD Handbooks which provide uniform guidance in some areas such as; quality program evaluation, statistical sampling, calibration requirements, etc. Nevertheless, these handbooks are not sufficient for implementing a uniform system for determining product quality.

The establishment of DCAS highlighted the problem of "Procedures" and the necessity for a standard set of procedures to be applied to the bulk of DoD procurements and material. However, the wide variation in the methods used by the military technical activities in specifying quality and reliability requirements is having an adverse effect on the effective implementation of these procedures. Further, since DCAS procedures were never circulated for official service coordination and were never service tested, they have not been totally accepted by the military departments for assuring the quality of some of their items.

ASPR 1-108 now dictates that no departmental procedures are to be published to supplement the ASPR. Thus a single set of procurement quality assurance procedures applicable to most of the DoD procurements must be developed. The absence of a total quality and reliability program which recognizes the different methods of developing defense weapons systems makes this a most difficult task.

This panel considers it essential that aggressive action be taken to establish a single set of procurement quality assurance procedures which can be effectively and efficiently applied to the bulk of DoD procurements and materiel. This single set of procedures should be published as a supplement to the ASPR.

Recommendations

It is recommended:

1. That the Deputy Secretary of Defense establish a task group; to define and develop a total quality and reliability program covering the entire product lift cycle, or to develop a system that will assure that adequate and just considerations are given to quality and reliability requirements throughout the entire product life cycle.

2. That DoD recognize in its policies and procedures that there are two methods of developing defense material (weapon systems) and that there is a distinct difference in the type of technical documentation that results from these two methods of development.

3. That ASD (I&L) assure that positive and timely actions are taken to develop a uniform set of quality assurance procedures that can be effectively and efficiently applied to the bulk of DoD procurements and that will satisfy the requirements and intent of ASPR 1-108.

REPORT OF PANEL 4

TITLE: Quality Assurance in Storage Operations

OBJECTIVE:

To assure the quality and reliability of materiel being issued for use from storage operations.

TOPICS DISCUSSED:

1. Quality of Material Upon Receipt by Storage Activities

2. Quality Deterioration of Material in Storage

3. Minority Positions

PARTICIPANTS

Chairman	Mr. Warren S. Koontz, Naval Ordnance Systems Command
Panelists	Mr. B. A. Matulaitis, HQS, Air Force
	Mr. Charles Ramsey, Middletown Air Materiel Area
	Mr. L. Weissenberger, FAA Depot, Oklahoma City
	Mr. Robert H. Ford, Naval Facilities Engineering Command
	Colonel T. C. McNeal, USAF, DCASR, Cleveland
	Mr. Elmer Ward, Defense Depot, Ogden, Utah
	Mr. Don Foy, Letterkenny Army Depot
	Mr. David H. Magathan, HQS, Army
	Mr. Roger F. Carroll, Jr., FSS, GSA
Recorder	Mr. Lawrence E. Grey, Jr., Naval Ammo Depot, Oahu
Monitor	Mr. Gordon J. Keefe, HQS, DSA

QUALITY OF MATERIAL UPON RECEIPT BY STORAGE ACTIVITIES

1. Definition of Storageability

There is considerable evidence of uneven practices and incompatibilities between the various services concerning thousands of line items assigned (often arbitrarily) limited shelf life or service life. This is particularly evident in the area of elastomeric materials, e.g., rubber goods, o-rings, gaskets, etc., where their shelf-life often arbitrarily governs the overhaul or rework intervals of major items. Another good example is acrylic aircraft paints where shelf life set by one agency is often twice that of another, even though it is an item common to all services. It is believed that the formalization and standardization of "storageability" requirements would provide significant improvements to the quality of material in storage and further would have a salutary effect upon the maintenance activity concerned.

There are many known instances where, by hindsight, it is obvious that if a few extra pennies had been spent to change or add a metal plating, or to make a minor change in packaging, or some other usually insignificant change there would have been a drastic increase in shelf-life reliability. It is felt that firm definitions and requirements for "storageability" should be considered in the design phase along with reliability, maintainability and value engineering in order that storage life of the end item be based on reasoned decisions rather than made arbitrarily.

It is well understood by the Panel, that from a technical standpoint, "storageability" is nothing new. Every designer, packaging engineer, etc. has always been involved. The same can be said for reliability, maintainability and value engineering. It is believed that the same reasoning that was used to define and separate these latter disciplines is equally applicable to "storageability." By giving "storageability" requirements proper definition and adequate visibility early enough in the design phase, and incorporating them in the production technical data package, considerable improvement in storage reliability with resultant cost savings should be effected.

Recommendation

It is recommended that OSD publish a DoD Directive requiring Services to spell out requirements for "storageability" in all major

procurement and in all procurement of material known to deteriorate seriously with time. It is recommended that the Defense Supply Agency be designated to develop this directive.

2. Inspection and Acceptance Requirements

Recent and continuing studies by Navy, Air Force, and the Aerospace Industries Association, among others, have come up with remarkably consistent findings on the quality of material being received by the Services particularly in the areas of spare parts procurement. The percentage of material received that fails to meet specifications ranges between 25 and 35 percent. About half of this percentage is unusable "as is" by the Armed Forces. It must be borne in mind that "spare parts" usually cover the great majority of all components making up a weapon system or other military equipment, e.g., every part of a military aircraft is given spare part support except the airframe (less wings). In the instance of the Navy investigators, most data on defective material were derived by exhaustive testing of the components involved by engineers and technicians in Navy laboratories and therefore the findings have complete technical documentation backup. Percentages of this material now ranging up to 50% are shipped directly to the storage or user activities under contractual arrangements specifying inspection and acceptance at destination. This material has not been inspected at source and the onus therefore is placed upon the storage activity to inspect (or test) as necessary. In most instances, the storage activity has not been provided with funds, personnel or necessary test and inspection facilities. He can provide normally only an "eyeball inspection" of packaging and marking.

The studies indicate that excessive defective material is being received from both major industry and small business sources. The concept of holding prime contractors responsible for the quality of their vendors' material is more often than not quickly deteriorated by "break-out buys", "fast-pay" contract procedures, particularly the areas of spare parts and follow-on procurement. It is common knowledge that former known high-quality producers have been consistently underbid due to their unwillingness to sacrifice quality. It is interesting to note that many of these same contractors are known quality producers of important commercial items and they are still able to compete successfully for their business. The findings of the AIA Quality Assurance Panel (Mr. J. Motolina, Jr) indicate that much of industry top management is not personally aware of, or does not personally understand these problems.

It is considered that the DoD must recognize this immediate situation because it impacts severely upon quality of material in storage and in

the hands of the combat forces. The only known means to correct the problem are by providing additional resources to the storage activities or by requiring valid source acceptance inspection. It is again emphasized that DoD materials in storage go directly to the aircraft squadrons, Armies, and Fleets for combat use and thus action at this level represents the last chance for the user.

Recommendation

It is recommended that DoD take necessary action to eliminate or reduce drastically the awarding of "acceptance at destination" contracts, including as a minimum all items, which if defective, would cause malfunctions or casualties of military weapons and combat equipments, or amend DoD Directive 4155.11 to require all storage activities to inspect and/or test material received under "acceptance at destination" contracts at the time of receipt from vendors/contractors, and provide the resources to do so.

3. Organization[1]

The intent of Para V B, the Responsibility Section, of the DoD Directive 4155.11 is not clear as to the organizational requirements for management of Quality Assurance functions. Para V B states: "The policy direction and responsibility for implementing DoD problems on Quality Assurance and Reliability Assurance of the material procured or produced, maintained, and stored shall be centralized within offices specified by the Secretaries of the Military Departments and the Director, Defense Supply Agency. The Quality and Reliability Assurance Policy function should be managed independently of other functions (e.g., procurement, production, maintenance and storage), but within approved manpower authorizations. This requirement does not preclude the grouping of various related functions within a large organization." Experience of the various military services has shown that the last sentence has made it possible to interpret this paragraph in many ways. The response to the directive has varied from establishment of an independent quality assurance agency to no action at all since the functions were already grouped within a large organization. Apparently the intent of the directive was to clarify the responsibility for the independent management of Quality and Reliability Assurance functions. If so, the directive has not succeeded.

[1]See minority position on this subject on page 132.

Recommendation

It is recommended that OSD (I&L) amend DoD Directive 4155.11 (Para V.B.) to delete authorization to combine quality assurance functions with other storage operations, if the intent of the directive is to require independent quality and reliability management. (See minority positions on this recommendation at end of report.)

4. Identification of Functions

The requirement for identification of the functions in DoD Directive 4155.11 that are to be performed by the depot organization responsible for execution of the storage quality and reliability program is not specific. The following is a list of functions that should be specified:

1. Perform procurement inspection/acceptance
2. Identify/classify returned materiel
3. Inspect stock transfers
4. Maintain quality history data
5. Schedule/perform cyclic inspection
6. Re-identify/reclassify materiel
7. Request disposition from commodity manager
8. Perform stock investigation
9. Perform issue inspection
10. Record/report inspection results (data feedback)
11. Inspect for modification work order compliance
12. Maintain technical data files
13. Conduct packaging inspection
14. Inspection/quality assurance planning
15. Perform evaluation and verification
16. Provide technical advice and assistance

These functions have been divided into three segments as indicated. The nine functions in the top segment are those which should be performed by a single organizational element. Items 10 through 14 are activities common to all of the first nine functions. Items 15 and 16 are assurance actions that are common to all of the preceding functions.

Recommendation

It is recommended that DoD Directive 4155.11 be amended to specify those quality control and reliability functions to be performed by a storage quality control organization.

5. Identification of Material

Storage activities report that considerable quantities of material are received with contractor part number or sub-contractor part number markings only. Identification of these materials creates a severe quality problem and is often responsible for the improper issue of the material. DSA has initiated action to require proper identification as part of the contract requirements.

Recommendation

It is recommended that material being procured for storage activities (or for the operating forces) be marked for identification by Federal Stock Number, where such numbers have been assigned.

QUALITY DETERIORATION OF MATERIAL IN STORAGE

1. Serviceability Standards

All Services report deficiencies in the area of Serviceability Standards. In the fields of explosive items and other hazardous materials, Army, Navy and Air Force have apparently adequate procedures and standards. Particularly in the case of Navy, other materials are sparsely covered.

Panel 4 concurred that to provide adequate coverage of all materials involved would require technical capabilities (duplication) not usually available to the storage activities to prepare such criteria. Also many items are used commonly between the services.

It was therefore concluded that the only possible sources of these Serviceability Standards would be available from the overall resources of the Commodity Managers for the particular items involved, and that where commonality exists that one agency should be designated to prepare the standards.

Recommendation

It is recommended that material managers such as Commodity Managers, Project Managers, Project Officers, System Program Director, etc., be required to provide storage activities with Storage Serviceability Standards for material receipt, storage, and issue in storage operations. These standards must define the minimum level to which deterioration can progress without impairment of serviceability and user satisfaction. It is further recommended that the Army be designated to prepare a DoD directive to this effect.

2. Utilization of Evaluation Facilities and Data

A considerable body of quality and reliability data on material in storage has been generated by test, evaluation, and maintenance functions. In some specific cases data have been fed back to design agencies, but for the most part this information is not available in usable form or if it is available it is not used by design activities. There have been efforts to systematize portions of this body of data, particularly in the area of materials deterioration, but these efforts have not been supported consistently. For instance, the work done by the National Science Foundation Center for the Prevention of Deterioration under DoD sponsorship has been stopped. Perhaps this effort was not

responsive to the needs of design agencies, or perhaps the existence of the center was not sufficiently publicized so that design engineers would utilize the information available. Similar efforts to systematize storage quality data have been made by various service activities, but these have usually been specialized in nature and accessible only to a limited group. There is a distinct vacuum in the area of technical data exchange regarding known deterioration rates and factors of common items in storage.

Similarly, the services all have test and evaluation facilities, some highly specialized and some general in nature. One example of highly advanced capability in this area, is the Navy's Quality Evaluation Laboratory complex. This group of activities represents the most well equipped and staffed group in the CONUS and Hawaii in the fields of both Destructive and Non-Destructive testing. Some cross-servicing is provided in these facilities but normally the established workload is such that utilization by other services cannot be accommodated. Arrangements to increase workload in these facilities will require study of potential capacity and requirements for additional personnel and funding support.

Recommendation

It is recommended that utilization of storage and user test and evaluation data be made mandatory and that necessary arrangements be made at the DoD level to utilize skills and facilities unique to any one service by all services in the quality evaluation of stored and service-held material.

3. Effect of Periodic Testing on Quality

Large scale tests in Navy on complex guided missiles, e. g., TARTAR, show that missiles which have not been given the usual periodic storage and shipboard tests perform about 10% higher in actual flight than missiles which have been repetitively tested. The TERRIER and SPARROW III results appear to be generating the same conclusions. The result in cutback of tests of these type materials in storage provides a drastic cutback in cost of missile maintenance.

Recommendation

It is recommended that OSD assign the Air Force and Navy to investigate the results of routine periodic storage testing of complex items (particularly electronic) on a selective basis, and weigh reliability degradation from these tests versus quality assurance gains.

MINORITY POSITIONS

Crganization

The AF representative (Hq USAF, AFSSSDC) does not agree that Par V B, DoD Directive 4155. 11 presents a problem. Policy direction and responsibility as outlined therein has been defined within the Air Force. Further clarification by OASD (I&L) is not required. The spirit and intent of the DoD Directive 4155. 11 will be carried out under the present Air Force organizational structure.

(Signed) Ben A. Matulaitis
Hq USAF (AFSSSDC)
Member, Panel 4

The discussion, solution and action relative to the subject problem presented by the panel with exception of the DAF representative, indicates grave problems exist because DoD Directive 4155. 11 allows flexibility by providing that quality assurance policy functions may be grouped with others in a larger organization. Although these problems and their attendant impacts are not stated, it is implied that quality assurance functions and programs of the services are suffering because of the flexibility currently provided in the Directive. Apparently concurring panel members feel it necessary that quality assurance must have an organization separate and apart from all others before it can be effective.

The writer believes that the policy guidance provided by DoD Directive 4155. 11 is provocative, indicative yet flexible as to its intent. It is not believed it was DoD's intent to unilaterally dictate to the service secretaries or Director DSA as to how they are to organize within their headquarters staffs, operational agencies and depots to accomplish the quality assurance functions assigned. It is also not believed that DoD intended that the services and DSA reorganize to create new independent staff and operational elements to accomplish the quality assurance and reliability functions.

The writer therefore does not agree that Paragraph V B, DoD Directive 4155. 11 presents a significant problem particularly with respect to the successful accomplishment of the storage quality assurance and reliability program at depot level or that the Directive requires clarification as to its intent.

(Signed) David H. Magathan
Representative, ODCSLOG
Hq, Department of the Army

REPORT OF PANEL 5

TITLE: Quality Assurance in Maintenance Operations

OBJECTIVE:

To assure that material reconditioned, maintained and modified for the Military Services meets requisite quality.

TOPICS DISCUSSED:

1. Consistent Quality Assurance at all Echelons of Maintenance
2. Continuity of Consecutive Modifications
3. Inspection Cognizance for Contract Maintenance
4. Reliability Management relating to Maintenance
5. Relationship between Reliability Analysis and Preventive Maintenance
6. Reconditioning Standards
7. Quality Standards for MAS and Grant Aid Materiel
8. Improved Reconditioning/Serviceability Standards for Attribute Characteristics
9. Use of Contractor Rejected Material in Maintenance Activities
10. Impact of Contract Waivers on Maintenance
11. Quality Control/Inspection Skills Gap
12. Reducing Maintenance Workload Through More Complete "Use" Instruction
13. Maintenance Technical Data
14. Deficiency Data Feedback

PARTICIPANTS

Chairman	Mr. O. A. Cocca, HQS, AFLC
Panelists	Colonel Lee M. Shelton, USAF, HQS, SAC
	Mr. Stanley Wirtschafter, Philadelphia Naval Shipyard
	Mr. J. F. Witten, HQS, Naval Material Command
	Colonel W. L. Alexander, USAF, HQS, DCAS
	Mr. W. R. Earnest, Defense Construction Supply Center
	Mr. Barney C. Gerke, Army Weapons Command
	Mr. Silas Williams, HQS, AMC
Recorder	Mr. Clarence E. Bobbs, Sacramento Air Materiel Area
Monitor	Mr. John R. Taylor, OASD (I&L)

CONSISTENT QUALITY ASSURANCE AT ALL ECHELONS OF MAINTENANCE

Ideally, all maintenance tasks (regardless of level) should be accomplished without flaw, thereby eliminating the necessity for inspection. In reality such utopian goals are seldom achieved, since humans are subject to errors of both action and judgment. To make matters worse, managers are often confronted with the situation where repairmen are guided with less than adequate technical instruction, and frequently lack the motivation to produce quality work on a sustained basis. The lack of uniform inspection procedures for repair work, coupled with the problem of selecting or identifying suitable personnel specialty codes for continued assignment to quality control duty, has been noted as a significant shortcoming, especially at the organizational maintenance level. Additionally, the lack of a method by which management can measure the effectiveness of local quality control programs is noted as a predominant weakness in achieving improvement at all levels.

Although inadequate inspection procedures and the lack of identity for quality control specialty codes are rather widely recognized problems, most Branches of the Services have directives and safeguards designed to:

1. Establish adequate standards of quality.

2. Stipulate the in-process point or time when inspection must occur.

3. Allocate adequately trained hardware specialists to a quality control function.

4. Delegate authority and provide the resource to insure correction of defects found during the inspection process.

While there are often serious deficiencies in the quality control functions operating within this framework, in the main, all the elements of a rudimentary program exist.

Since the maintenance quality control function is deficient as it presently exists, and varies widely even within a single Military Service, it is evident that a management plan and associated funding budget are needed to standardize the program and provide some degree of operational consistency. There is an attendant need for management to be able to evaluate the effectiveness of quality programs in order to bring about the required improvements. Further, the management plan must provide for a clear, well-defined channel of communication, funding requirements and other associated quality assurance problems throughout all echelons

of maintenanace within and between Services. The magnitude of the maintenance program, both in terms of manpower and dollars, dictates that this problem receive immediate DoD attention.

Recommendations

It is recommended:

1. That a DoD directive patterned after Nav Ships Instruction 5450.148 - Standard Naval Shipyard Regulations be prepared which will strengthen quality assurance and provide total program orientation for all levels of maintenance. The directive must establish the concept of operation and delineate organizational lines of quality assurance communication and responsibilities (from top to bottom) for the maintenance programs for each Service and lead to improved consistency at all echelons.

2. That DoD initiate a Tri-Service Project to test the use of Mil-Q-9858A (Quality Program Requirements) con ept in depot overhaul facilities. This test to be confined to one depot per Service.

3. A DoD task group be established to develop a handbook for general guidance in performing maintenance quality control. This handbook would be useful to organizational level maintenance managers in developing management plans that are generally consistent with the depot/contract program.

4. That DoD initiate action to identify quality control specialists, both civilian and military, with a functional code in order to provide for continuity of duty assignment.

5. That DoD require the Services to establish within their budget an identified funding structure of appropriate breakout to cover all aspects of the quality control program as related to maintenance activities at depot level and above.

CONTINUITY OF CONSECUTIVE MODIFICATIONS

Weapon systems design modifications are often carried out without appropriate recognition of pertinent preceding actions, or those that may follow. Frequently modifications are completed, only to receive another modification which requires disassembly and reassembly. It is not uncommon for modifications to reach equipment out of sequence, with the effect that modifications are sometimes undertaken on equipment not to the latest "configuration." This practice increases the chance of contaminating the unit as well as contributing to the likelihood of serious maintenance errors. Thus, the improved reliability inherent in the modification may be negated, with an additional waste of maintenance dollars.

The need for a centralized system of planned, orderly control of the modification process is evident. This control should be time phased, yet flexible enough to handle situations of urgency that may affect safety. Also, scheduled modification actions relate directly to scheduled maintenance actions.

Analysis of approximately 1000 check-in discrepancies of a shipboard weapon installation revealed over 75% of the total were the combined effects of poor installation and maintenance practices. Notwithstanding usual design and production deficiencies, such statistics indicate additional responsibility in areas relating to controlled handling of modifications and maintenance.

It is frequently very difficult to isolate the inter-faces of pure design complicity vs pure maintenance when dissecting mass deficiency data. Therefore, a host of "make-do" modifications often evolve which provide an interim fix to locally identified problems. The hazard of this modus operandi is that later modifications sometimes negate the result of an earlier fix, or in correcting deficiencies associated with one functional area (e.g., design) result in the occurrence of a new problem appearing in another function area (e.g., quality control).

The system must recognize the need for introducing conceptual and developmental inputs into the system life cycle in an effort to minimize the amount of "continuing engineering" performed on the item.

Recommendation

It is recommended that a more effective centralized Service control and review of maintenance modification publications be established to insure timely, consecutive scheduled incorporation of modifications. This recommendation should also be incorporated in the DoD configuration management program.

INSPECTION COGNIZANCE FOR CONTRACT MAINTENANCE[1]

To insure consistent quality of contract and depot maintenance, there is a need to re-examine those specialized contract maintenance facilities to ascertain which should be reassigned to the contracting Service.

Effective maintenance management dictates that the System Support manager must have more direct control and access for the exercise of technical direction over all specialized maintenance and repair activities engaged in the maintenance, overhaul repair and modification of the weapons for which he is charged. This especially includes quality control and the planning functions related thereto.

As an extension of the organic depot level Service activity, contract maintenance is equally a part of the SSM's responsibility. Administration of this type contract by an agency other than the initiating Service poses special problems in the input of reparables, interpretation of work specifications, supply support, and quality control (from a manpower standpoint, the latter function represents 40-45% of the in-plant Government workload). Split responsibilities in these areas have resulted in communications/control problems - primarily as relates to interpretation of requirements - that has effected quality control performance.

The principal problems pertaining to quality control at contract maintenance activities is related to the extremely difficult problem of writing rework specifications for a product which is produced from a RAW material input (reparable item) which is non-uniform in; age, source, configuration, expended service life and as received condition.

The nature of the work performed to produce the product is also highly variable; some items require major rework and modification, others require only minor adjustment and repair. Under these conditions the acceptable level of quality is not fixed. Contract administration (depending upon the type of contract) ranges from trying to prevent the contractor from Gold Plating, (CPFF and Job Order Contracts) to trying to insure an acceptable level of performance (fixed priced contracts). In a situation with this large number of independent variables it is essential to have "user oriented" quality control personnel who are well versed in technical specifics and in close contact with the using Services technical authorities.

[1] See minority position on this subject on page 141.

A related problem is the necessity for performing analytical engineering examination of failed items received for rework. These examinations may be for the purposes of revising engineering or maintenance deficiencies, investigating accidents, developing inputs to improve schedules maintenance component life limitations or rework specifications or to verify or determine specific problems defined in mechanized data collection systems. These analyses are closely related to internal functions of the using Services and should be performed by personnel who also are well-versed in the technical specific and technical management practices of the using Service.

The Defense Contract Administration Services (DCAS) organization was established as the central DoD contract administration Service organization, and although it was originally planned that DCAS would be responsible for contract management of all plants performing under contract to the Military Services, this was not totally practical nor feasible. Although most plants come under DCAS control, approximately 70 major prime contractor facilities were retained by the present Service.

Similarly, a number of contract maintenance facilities have been reassigned to the parent Service. Although it was originally intended that these would include the facilities which are mainly specialized contract overhaul operations (i. e., engaged solely in specialized maintenance, repair, overhaul and modification), this criteria has not been followed, and a number of these specialized contractors are still retained by DCAS.

For more consistent and effective control over the DoD's major specialized repair activities (combined organic and contract), especially relating to consistent over-all quality control operation, the entire contract maintenance program should be re-examined. Not only is the visible control of total maintenance by the SSM essential to responsive ultimate customer service, this combined responsibility makes it possible for the parent service to effect a total maintenance reaction, and leading to flexibility in drawing on highly skilled organic maintenance inspectors to augment in-plant Government personnel in administering/interpreting contract requirements when necessary.

Recommendation

It is recommended that the Services/DCAS/OSD follow through on the original concept to reassign maintenance contract administration to the parent Service for those contractor facilities primarily engaged in specialized maintenance, repair, overhaul and modification.

Minority Position

We, the undersigned, nonconcur with the statement of the problem "Inspection Cognizance for Contract Maintenance," since it is not germane to the mission assigned to Panel Number 5.

Some of the points raised in discussion of the problem seem to indicate a need for the parent Service to assign technical guidance personnel to specific plants for specific contracts. Such assignments are now authorized. In some instances, when such assignments are warranted and made, economics may dictate plant assignment to the parent Service. Current policy (OSD) makes provision for such arrangements.

Therefore, we do not concur with Panel 5's presentation on "Inspection Cognizance for Contract Maintenance."

B. C. GERKE
Member, Panel 5

S. WILLIAMS
Member, Panel 5

RELIABILITY MANAGEMENT RELATING TO MAINTENANCE

Much effort has gone into the development of highly sophisticated reliability programs for select weapons systems and manned space vehicles. These have proven very effective. Subsequently, attention was directed to equipments in every day use, and newly designed equipment built predominantly on standard design principles, and from well-tested parts. Educational programs have been developed for reliability management. Focal points for reliability management have been established within the depot organizations, and testing/repair programs oriented to specific reliability requirements have been initiated. In order to fully realize the intended goal of this program, the same kind of discipline must continue throughout the life of the equipment, including the depot operation. Substitution of parts of unknown reliability for high reliability component parts can appreciably degrade equipment reliability. For effective reliability management, consideration should be given to requiring a reliability assurance test after repair that is consistent with the requirement levied on the new item. DoD policy on the relationship of reliability management to depot level operations has not been defined.

Recommendation

It is recommended that OSD establish a policy to provide for a concerted effort by each Service to develop and expand the use of reliability tests when reconditioning reparable items. The purpose of this policy is to insure that replacement items do not degrade the quality and reliability of the original production.

RELATIONSHIP BETWEEN RELIABILITY ANALYSIS AND PREVENTIVE MAINTENANCE

Present DoD Instructions (3200.6/9/4100.35) give effective emphasis to reliability and maintainability for programs in the $25 - 100 million R&D projects. Action is required to place equivalent emphasis on procurements of major Government-furnished equipment items and components. DoD policies for reliability and maintainability programs are only partially considered in a number of DoD instructions; e.g., 3200.6 - Technical Development Plan Preparation; 3200.9 - Concept Formulation; 4100.35 - Integrated Logistic Support; and 3232.1 - Maintenance Engineering Policy.

Maintenance engineering analysis (when performed) often fails to identify and document in precise quantitative terms the vital product attributes which are essential to effective quality control.

Basically, preventive maintenance and scheduled maintenance are synonomous (i.e., the sum of actions performed on equipment contributes to uninterrupted operation within design limitations). The same parallel may be drawn for corrective or unscheduled maintenance (i.e., the sum of actions required to restore equipment to operational adequacy).

Data are available which indicate that significant amounts of maintenance work now being done fall into the unscheduled category, despite efforts to prepare and issure complete maintenance work packages.

Work issuances, in these cases, call for considerable "open and inspect" actions as the means for identifying what maintenance should be performed. Frequently, such actions do little more than expose obvious surface conditions - with the result that other more important areas of interest are unattended. Effects of this include unreliable estimates of work required as well as creating a void in the feedback of essential reliability data.

Present demands placed on weapon system reliability and maintainability make it mandatory that scheduled maintenance plans be available at the start of maintenance operations. This can only be done through meaningful reliability analysis.

Recommendation

It is recommended that OSD issue a policy instruction that makes specific reference to the working relationship between quality assurance and reliability and maintainability and it should clarify and consolidate requirements now appearing in DoD Instructions 3200. 6, 3200. 9, 4100. 35 and 3231. 1 to include all reparable systems, components and equipments procured by the DoD. This policy should further emphasize the importance of more active participation of capable quality control personnel in the normal process of work planning, from design through ultimate fabrication and test.

RECONDITIONING STANDARDS

DoD policy covering maintenance reconditioning is inadequate. Under the current program, Service maintenance operations vary greatly - from complete rebuild, i.e., restoring equipment to "like-new" condition, to minimum essential repair which result merely in correcting operating deficiencies on fairly aged equipment. This is in part due to basic differences in Service policies.

The Services have published independent and uncoordinated repair Standards for similarly maintained equipments. This is also typical within a Service (e.g., Army), when experience has shown that the TM series of publications is inadequate for contractual repair purposes.

Recognizing its problem, the Army has published guidance to its commodity Commands (AMC Reg 310-23 and 750-7) for development and publication of maintenance reconditioning standards. However, more specific policy and instructions for more uniform DoD-wide program is still required.

Recommendations

It is recommended:

1. That DoD consider development of a more uniform policy relating to reconditioning standards.

2. That DoD issue procedural guidance to all DoD commodity managers for the development of maintenance reconditioning standards. Such an instruction would assign responsibility for development of such standards, establish a standard format (which would require acceptable wear tolerances on all critical characteristics), and would be Service/industry coordinated and acceptable for commercial and Government repair.

QUALITY STANDARDS FOR MAS AND GRANT AID MATERIEL

Frequent reports from recipient countries of the Grant Aid and Military Assistance Sales Program indicate that materiel being supplied lacks quality, uniformity, contains shortages, and is not in conformance with the Sales Agreement.

There is often controversy between the shipping depot and recipient country regarding the requirements of the materiel. This results from the fact that although the reconditioned materiel. This results from the fact that although the reconditioned materiel conforms to the established reconditioning standards for the selling Service, it does not conform to the requirements of the buying country.

These conditions exist because quality standards and regulations for MAS and Grant Aid Materiel are ambiguous, lack uniformity, and are not sufficiently definitive to assure that material supplied is of a quality level which meets Military Sales Agreements and Grant Aid requirements.

Recommendations

It is recommended:

1. That pertinent and specific DoD regulations be published establishing basic requirements for all materiel destined for Military Assistance Sales Program and the Grant Aid Program.

2. That detailed and specific directives be issued within each Service to assure that materiel destined for MAS and Grant Aid conform with the Sales Agreement negotiated between the buying country and the selling Service.

IMPROVED RECONDITIONING/SERVICEABILITY STANDARDS FOR ATTRIBUTE CHARACTERISTICS

Reconditioning and Serviceability Standards use such vague terms for attribute characteristics (e.g., excessively pitted, excessively scratched, excessive roughness, discolored, etc) that the individual repairing/maintaining or inspecting the completed work is shouldered with the responsibility of quantifying these characteristics on his own.

This is a major problem and not exclusively that of maintenance. Vague, generally stated requirements of this nature consume tremendous manhours in attempting to reconcile differences in opinion and interpretation of intent. As interpretive characteristics, only after many thousands of hours of experience and discussion is agreement generally reached, and then only on an individual installation or facility basis. Illustrative of the problem (and typical) is a sampling of maintenance/inspection characteristics taken from the first 32 pages of a maintenance manual for a gun fire control systems:

1. Scrupulously clean.
2. Excessive vibration.
3. Evenly spaced.
4. Should line up.
5. Clean if necessary.
6. Inspect.
7. Should be uniform.
8. Should be approximately.
9. Replace if worn.
10. Replace if condition warrants.
11. Will depend on weather conditions.

Such stated requirements usually indicate the lack of regard for the later confusion that may result, and for the more important reason that the responsibility for making the ultimate judgment (and hence establishing the actual standard) is being passed onto the worker and the inspector.

For measurable parameters, it is inexcusable if maintenance standards do not specify quantified acceptable tolerances/allowances, particularly where defects have critical (MIL-STD-105 definition) application.

Where the only choice that exists is to treat characteristics on a subjective or attribute basis, maximum effort should be made by standards groups to develop more discriminating comparison standards, interpretive guides, including photographs, etc., wherever possible. It is obvious that this problem cannot be resolved over night. However, a very major effort in this area is long overdue. Photographic and printing techniques have advanced to the point that a reasonable effort to expand on a DoD-wide basis on what has already been done in this area (e.g., soldering guides - Navy Avionics QWS-1000a and NAVWEPS 00-15PA-1) can pay real dividends.

Recommendations

It is recommended:

1. That OSD issue a firm policy (letter) that acknowledges the need for increased effort in developing comparison/interpretive standards for use in distinguishing attribute characteristics such as color, fit, pitting, finish, damage, etc.

2. That DoD take more aggressive action to bring the many individual Service and Command efforts together to evolve standards for DoD-wide use. Needed is a DoD designated activity to function as a clearing house and coordinating agency.

3. That DoD/Industry committee be established to determine what standards exist, and to identify those which should be established, encourage industry groups to develop interpretive standards for specific product and functional areas, and monitor the initial phase of this program.

4. That the Services/DSA activities having responsibility for development of maintenance reconditioning and quality standards make an intense, more deliberate effort to incorporate quantified tolerances/allowances, including method of test.

USE OF CONTRACTOR REJECTED MATERIAL IN MAINTENANCE ACTIVITIES

The present system for disposal of contractor generated out-of-specification material often permits these materials to inadvertently enter the military supply system for use by maintenance activities as result of later purchase action.

There is no DoD common policy which would act as a control to prevent inadvertent procurement and reuse of contractor discarded material in our depot/contract maintenance facilities. MIL-Q-9858A (para 6.5) stipulates that the contractor shall make known to the Government on request the data associated with the costs and losses in connection with scrap and with rework on out-of-specification material. Other than this requirement, there is no standard method for verifying a contractor's disposition of his scrap/substandard material.

Recommendations

It is recommended:

1. That DoD establish a clear, common policy regarding re-use of out-of-specification material.

2. That the ASPR be amended to require that Service purchases, regardless of quantity or value, include a statement to the effect that supplies on order shall not be "used or surplus material unless agreed to by the Government," thereby placing a legal as well as moral responsibility on the supplier.

IMPACT OF CONTRACT WAIVERS ON MAINTENANCE

While repairing and/or testing materials at depots, it is found at times that all characteristics do not meet tolerances contained in appropriate specifications as a result of contract waivers granted during the initital procurement.

After much time and effort is expended by shop personnel trouble shooting equipment scheduled for maintenance, contact is sometimes made with the appropriate engineering agency, with a request for additional information on why tolerances exceed specification. At this point, it is occasionally learned that a waiver was granted to the contractor during procurement and the contract specified tolerances were never met.

In assessing what might be done to overcome this informational deficiency on an interim basis, certain actions are possible. For example, in the event that material shipped is non-conforming and the waiver did not require an official engineering change notice, some type of permanent documentation might accompany the equipment. As another possibility, the Quality Assurance Representative might include this information on the DD-250 shipping document, although this is not too promising a solution since the DD-250 usually does not stay with the equipment throughout its life span.

For a more lasting correction to oversome this problem, if nonconformance signficantly affects a dimensional or test characteristic of the product, a standard DoD form could be developed which could be affixed to and accompany the item or equipment. This form could be completed by the contractor, verified by the Quality Assurance Representative, and include such information as: Extent of noncomformance, contractor, contract number, drawing numbers, specification, lot and serial numbers, waiver number, approving authority and date. In any event, a study could be made to ascertain the extent of this problem in field activities, and whether it occurs frequently enough to warrant development of this type documentation. This study might also ascertain whether the waivers granted are in fact affecting characteristics which in turn effect the operation of the equipment.

Recommendation

It is recommended that DoD establish a task group to ascertain in greater detail the extent of this problem, and develop a plan of action and proposed rationale for its resolution.

QUALITY CONTROL/INSPECTION SKILLS GAP

It is a well recognized fact, that in the past quarter century, the complexity and sophistication of much of our defense equipment has increased at an explosive rate. In very recent years, however, it is becoming increasingly evident that inspection skills and testing technology are not keeping pace - in fact, are falling behind at an alarming rate.

This problem is not unique to maintenance inspection, but applies generally to the inspection field, and to a larger degree, to equipment operators, users, and servicing personnel (e.g., Maintenance Specialists). Moreover, the problem of lagging inspection skills is further aggravated by the fact that a program designed to foster development of new, advanced testing methodology is generally lacking. Since these are inter-dependent and play such an important role in the maintenance area, they represent a major maintenance quality control problem.

Only recently exotic processes, e.g., microminiturization, electron beam welding, electro-chemical machining, high energy-rate-forming, laser welding, diffusion bonding, honey-combing, electro-chemical bonding and hydro-static extrusion represented production technology now considered rather commonplace. Electronic gear of greatly increased complexity, laser applications, high stress/high temperature materials, etc., reflect but a few of the material developments that have been responsible for some of the unusual and more challenging demands on our inspection/testing program.

Generally, the scientist and engineer have teamed up in an effort to advance product, without proportionate attention to upgrading inspection skills and new testing technology. Lack of a parallel and proportionate attention to the problems of inspection and testing causes the lag to become more pronounced with each passing year. For example, stress limits and environmental demands have led to exotic materials with unbelievable stress-temperature performance. However, conventional, present day material testing (e.g., pull type tensile test methods and conventional stress measuring techniques) are no longer adequate for these new high stress-temperature materials. It is no longer adequate to induce the failures of a few items, take average results and apply a "factor of safety." Test methods which are dynamic and assess internal molecular force-changes are needed. We need to know the crystalline molecular condition of solid rocket motors, not that separation has or had not occurred. Laminations, sandwich construction, special bonding methods, etc., all tend to point up the antiquity of present methods. But nothing really exists to take their place, and little has been done to fill

this void. Radiographic techniques, ultrasonics, eddy current, and other longstanding techniques are being improved, but with possible exception of infra-red (applications for detection micro-electronic defects) no really new methods have appeared on the inspection/testing scene.

Inspectors are frequently placed in the position of competing with engineers and scientists. In the competition to advance our defense equipment technologically, highly technical skills are often unavailable to inspection to meet the demands relating to the interpretation of important test results. Efforts to simplify use or tests of "next generation" equipment often suffers because of the shortage of technical skills to perform the immediate tests and interpret results. There is ample evidence of this in such present-day equipment design programs as reliability, maintainability, availability, etc. These are terms that have become a part of the scientist/engineers drive to achieve equipment simplicity. The paradox, however, is that only too often, relatively little is really done to relieve the inspector of an interpretive responsibility resulting from the failure to prescribe clear, meaningful, discriminating maintainability tests, reliability tests, etc.

Traditionally, R&D dollars concentrate on end item equipment. Occasionally, and usually more by accident than design, limited budget dollars are diverted to the problem of developing testing equipment specially designed for use in testing new products. This is the exception, not the rule, however, and equally complex test equipment is not the answer unless it relieves the inspector of an interpretive role.

Self checking equipment (e.g., the USAF's VATE, Versatile Automatic Testing Equipment), automatic and built-in self checking equipment, and computerized production control methods represent a partial solution to this problem. But too often, deficiencies or malfunction of these equipments placed a similar burden on inspection.

Training of inspectors and quality control personnel in our Service School has been intensified in the past 10 years. Although training is needed, this is not the answer to solving the equipment-man competance gap. The resource and effort required to technologically update the man at the same pace as the equipment cannot possibly be overcome by training alone.

Recommendations

It is recommended:

1. That service programs devote increased attention to developing special test equipment which relieves the burden on the inspector and

replaces subjective human evaluation with greater mechanical accuracy and objectivity.

2. That future DoD defense equipment budget begin to take account of the need for dollars for specialized test equipment. This does not mean more complex test equipment, rather that the Services should undertake a joint program for the development of more adaptive and perceptive destructive and non-destructive test methods.

3. That since equipment sophistication is felt principally by user and maintenance activities, an aggressive program be undertaken to establish a quantitative means for elating (equating) equipment, combat effectiveness, equipment sophistication, and skills levels, as a partial means for establishing optimum design.

4. That increased emphasis be placed by all Services/DSA on quantified, meaningful requirements for equipment reliability and maintainability, including suitable demonstration provisions.

REDUCING MAINTENANCE WORKLOAD THROUGH MORE COMPLETE "USE" INSTRUCTION

Lack of adequate knowledge of the capabilities and limitations of equipment by the user results in misuse, causing premature failure or deterioration of quality.

Normally this is considered an "operating" manual problem, and it is recognized that one aspect of the solution is to include equipment capability information in operating manuals. This is not the complete solution, however, to overcome deficiencies frequently resulting in increased maintenance workload caused by lack of equipment knowledge. Lack of knowledge usually reflects inadequate training, but it is believed that improvement of the operator's manual alone is not sufficient to overcome the problem created by an influx into the supply system of newer and more complex items for use by the rank-and-file fighting man. The gravitation of more complex equipments downward, the need to draw on lower skilled/IQ people to operate a more complex spectra of fighting equipment, and a human reluctance to "take the time" to read operator use/maintenance publications necessitates that we look to other ways to aid in solving this problem.

It is generally accepted that maintenance workload is only too often the result of misuse, rather than use. The best quality effort (design and conformance) cannot overcome the problem of misunderstanding, misuse or abuse. Too often equipment identified for overhaul and repair indicates that the failure was not due to wearout or normal life expectancy, but to improper field use. To overcome this costly overhaul repair burden, certain actions are considered appropriate.

To minimize user misuse requires personal contact concerning equipment capabilities and limitations. Manuals should be revised to contain additional information where appropriate, but is is also necessary to recognize when best to augment manual improvement with equipment indoctrination of personnel from Command through operating levels.

One major Service activity felt this particular problem with new/modified items to be of sufficient importance as to warrant special attention. Accordingly, it approached the problem with considerable success by organizing and conducting a New Equipment Training (NET) program, consisting of:

1. Material Introductory Letters (MILs) to Commanders with special or unique information, including any special skill/operating requirements for items prior to entry into the supply system.

2. Analysis of MOS inventory requirements.

3. Development of appropriate NET packets.

4. Furnishing New Material Introductory Briefing Teams to field Commanders, when appropriate.

5. Conducting NET courses for key training personnel.

Recommendations

It is recommended:

1. That an OSD policy be issued covering the use of New Material Introductory Briefing Teams.

2. That the Services/DSA exchange information relating to this program.

MAINTENANCE TECHNICAL DATA

Technical data furnished to maintenance activities (contract, depot, organization) lack effective, detailed quality assurance provisions, with the effect that quite often quality production cannot be assured. Regarding engineering drawings, the problem is not uniform. Drawings are often found to be inadequate, and frequently cannot be obtained, or require considerable effort.

The basic deficiency of technical data (T/Os, manuals, etc.) stems from the lack of a section and/or sufficient detail devoted to quality assurance. While a requirement for inspections usually exists, specifics relative to the method of test, number to be tested and detailed instruction as to just how the item will be tested and what it will be tested for is not usually provided. This is fundamentally a problem stemming from the format used, and could be corrected by bringing the format of technical manuals more closely into line with that used for specifications.

The problem relative to engineering drawing inadequacies is universal and has no specific domain in the maintenance area. Deficiencies range from errors of omission to errors of commission. The question of just what should appear on an engineering drawing as opposed to other technical data items constitutes the core of the matter.

Typical of deficiencies noted for drawings, and applicable at least in part to technical manuals, include:

1. Tolerances, duplicated or missing.

2. Basic dimensions, duplicated or missing.

3. Dimensions specified to "Points in Space" and, as such, not capable of verification.

4. Disagreements between notes and dimensions/tolerances.

5. Lack of clarity of notes.

6. Lack of field tolerances.

7. Disregard of tolerance accumulations.

8. Elaborate details and artistry when simple line drawings would be more effective and economical.

Traditionally, the drawing was expected to provide merely the knowledge of shape and form. Added, have been all or part of the

characteristics just discussed, with little or no predictable pattern. Considering the sheer weight of verification responsibility in today's manufacturing or maintenance environment, the need for resolving this problem is readily apparent. Until there is collateral agreement as to the standard format of an engineering drawing versus other considerations of "technical data packages" little improvement can be expected.

Recommendations

It is recommended:

1. That the DoD standardize the format of Maintenance Technical Manuals by bringing them more closely into line with specifications relative to quality assurance. Strong formal quality assurance provisions similar to those provided by specifications would contribute immensely to improving the adequacy of these manuals.

2. That a comprehensive inter-service evaluation be made to ascertain which Service program is proving most effective in getting, maintaining, and issuing engineering drawings which are generally adequate from a maintenance quality assurance viewpoint. The information obtained from this study should be used to improve Mil-D-1000 (Engineering Drawings and Associated Lists) and related Quality Control Directives.

DEFICIENCY DATA FEEDBACK

The importance of quality and reliability feedback data systems is generally recognized throughout Government and industry. DoD Directive 4155.11, "Improved Management for Quality and Reliability Assurance of Materiel," highlights the need for compiling and using this quality information in Procurement, Storage, Maintenance and Field Service; however, there continue to be significant gaps in obtaining and properly using these vital data.

Maintenance data in existence throughout the DoD were usually designed for organizational and field maintenance. Although much of the data generated by these systems is useful for such activities as adjusting inspection intervals/parts consumption data, the data generated are usually not adequate, nor were they intended for use in feeding back dificiency information.

In a recent study on deficiency data feedback, it was observed that on the average 2.4 months elapsed from time the failures (deficiencies) were observed until the reports were received at the source production activity. Assuming the discrepancy to be production induced, this time delay may well have permitted large numbers of defective items being delivered to service organizations. With a lack of timely, pertinent and definitive deficiency information, management action to provide the climate for low cost-high quality production is hampered.

In addition, there are several other causes for concern over adequacy of the deficiency feedback reporting systems such as:

1. Is deficiency reporting considered wasted time?

2. Is there lack of payoff to the reporting activity, i.e., lack of evidence of corrective or preventive action?

3. Is the effort too costly?

4. Is there failure to follow established systems?

5. Lack of objective and procedural guidance on what to report, i.e., minor or relatively inconsequential vs significant deficiencies.

Recommendations

It is recommended:

1. That OSD initiate action to examine the existing deficiency reporting systems to determine which of these will provide the most

complete and timely feedback of quality control deficiency data. This system should then receive priority attention for service-wide implementation.

2. That OSD take action to address the attendant major problem of coordinating the data feedback systems required by DoDD 3232.1-DoD Maintenance Engineering Program, DoDD 4100.35 - Development of Integrated Logistic Support for Systems and Equipments, DoDI 7220.14 - Uniform Cost Accounting for Depot Maintenance, DoDI 7730.25 - Equipment Distribution and Condition (EDAC) - Statistical Reporting System, Proposed DoD - Configuration Accounting and Proposed DoD - Resources Management; and to place these actions in harmony with the intent of DoDD 5000.11 - Data Elements and Data Codes Standardization Program and DoDI5000.12 - Data Elements and Data Codes Standardization Procedures as they pertain to data element standardization.

REPORT OF PANEL 6

TITLE: Reliability and Maintainability Assessment

OBJECTIVE:

To recommend actions essential to the quantitative assessment of materiel reliability and maintainability during all phases of its life cycle.

TOPICS DISCUSSED:

1. Consistent Assessment Criteria for Reliability/Maintainability

2. Reliability/Maintainability Prediction Techniques

3. Test Programs as an Input to Reliability/Maintainability Assessment

4. Field Data Feedback

5. Reliability and Maintainability Data Storage and Retrieval

6. Research in and Validation of Reliability and Maintainability Assessment Techniques

7. Use of Reliability and Maintainability Assessment Results by Management

8. Interservice Coordination

PARTICIPANTS

Chairman	Mr. Robert O. Black, Army Missile Command
Panelists	Colonel William F. Stevens, USAF, HQS AFSC
	Mr. Frank Ruther, HQS AFLC
	Mr. Jacobs Sacks, Naval Ships Systems Command
	Dr. William R. Pabst, Naval Ordnance Systems Command
	Mr. L. Kaiser, DCASR, Chicago
	Mr. L. Bonosevich, Defense Electronics Supply Center
	Mr. Abraham I. Moskovitz, HQS NASA
	Mr. Norman Krause, HQS AMC
Recorder	1st Lt Maxwell E. Westmoreland, Army Missile Command
Monitor	Colonel William I. Bedell, HQS Air Force

CONSISTENT ASSESSMENT CRITERIA FOR RELIABILITY/MAINTAINABILITY

If the DoD reliability and maintainability assessment program is to be an effective part of total program management, it must provide decision makers with consistent measures of reliability and maintainability. A review of the assessment efforts currently under way in all three departments resulted in two conclusions. First, with some exceptions (such as strategic delivery systems where JCS and OSD have imposed detailed requirements) the departments do not apply consistent measures of reliability and maintainability for systems. This lack of consistency is not readily apparent but is revealed in differences in what is meant by a reliable system. The second, and even more serious problem, is the lack of consistency across the life cycle. This is usually manifest in the form of restricted definitions of a reliable system during early development which are gradually replaced by more realistic definition of system reliability as the system is deployed.

Panel 6 reviewed the following documents to determine if DoD policy guidance in this area could be improved: DoD Instruction 3200.6, DoD Directive 3200.9, DoD Directive 4100.35, and DoD Directive 4155.11. From the point of view of an adequate assessment program, it was considered essential that DoD policy meet the following criteria:

1. Reasonable consistency among the departments,

2. A consistent basis for assessment throughout the life cycle, and

3. A means of relating measured or predicted reliability and maintainability to one another or to other parameters effecting overall system mission performance.

From this review it is clear that the departments have issued or will issue implementing directives requiring life cycle assessment, however, it is also clear that the current departmental directives fail to meet all of the above criteria.

Although there is a DoD goal of achieving an optimal balance between system effectiveness, performance, schedule, and total cost, there is no clear-cut DoD policy that requires a comprehensive, integrated, single thread effectiveness evaluation program throughout all phases of a weapon system life cycle. Since system effectiveness analysis can be a vital and dynamic decision-making tool, it can provide greater insight into such areas as:

1. Establishing attainable requirements.
2. Probability of mission success.
3. Isolation of problem areas.
4. Ranking the criticality of problems.
5. Evaluation of alternative solutions.

An analysis of pertinent DoD Directives provide the following:

3200.6 (Reporting of Research, Development and Engineering Program Information) requires consideration of reliability and maintainability in the preparation of requirements documents and technical development plans. It is a permissive document in that it says "...due consideration shall be given to all characteristics, including reliability and maintainability, in the early planning and feasibility study stages, and comprehensive reliability and maintainability programs are expected for operational development projects. It is intended that both the human and hardware aspects of reliability and maintainability be considered. The goal is a balanced and integrated effort aimed at optimizing operational effectiveness, total cost and early availability." The requirement is weak, doesn't start early enough; e. g., should start with Advanced Development Objectives (ADO's) and is not applicable beyond the definition phase. There are no provisions for passing information (data) or analysis (models) into acquisition.

3200.9 (Initiation of Engineering and Operational System Development) is the only DoD Directive that addresses the total system/cost effectiveness evaluation. It does not provide a framework or even ground rules for the conduct of system effectiveness evaluation thus comparisons between system and/or trade-off's within systems are difficult if not meaningless. It addresses only the concept formulation and contract definition phases. It does not provide for passing to the acquisition phase that data and analysis performed for contract definition nor does it require a later audit to determine or compare hardware performance with contract definition base line prediction.

4100.35 (Development of Integrated Logistic Support for Systems Equipments) is of concern to Panel 6 in that it requires the use of reliability and maintainability data and analysis along with total system analysis in the implementation of the integrated logistic concept. Additionally, it requires logistic matters and costs to be considered from the trade-offs in feasibility studies and the concept formulation phase into the system operational phase. It recognizes the interrelationship of the functional disciplines, and directs that they be mutually supporting.

DoD Directive 4155.11 (Improved Management for Quality and Reliability Assurance of Materiel) treats quality as a functional activity applicable during the acquisition and operational phase. It attempts to include reliability by use of the term in several places equated with quality. In fact, one could strike the word "reliability" each place it appears and not affect the directive in any way. The point being, there exists a separate and well defined reliability program apart from the quality assurance program. The quality assurance program is a separate and distinct program, the two are not and cannot be treated meaningfully in the same directive. Therefore, the term "reliability" should be deleted from DoD Directive 4155.11.

Thus at present, there is no requirement for cradle-to-grave evaluation of the overall effectiveness of military weapon systems. There is considerable emphasis on this during the concept formulation and contract definition phases. However, during engineering design and production, there is no requirement for continuing evaluation by DoD. Effectiveness evaluation programs are being conducted by a few of our Defense contractors during design and production to satisfy their internal needs. However, it is questionable whether these contribute to the mainstream of the system program or are little more than academic exercises. At any rate, customer and contractor objectives cannot be expected to be identical; i. e., "best" in a contractor's eyes may not be "best" from a military viewpoint. Interest picks up somewhat during the operational phase, but the requirements for operational evaluations vary considerably. Variations occur not only between the military departments, but even between the developer and user within a single department. Major program changes can be made and are being made without benefit of thorough evaluation in terms of impact on total system/cost effectiveness. Included are Engineering Change Proposals (ECP's), changes in operating or maintenance concepts, changes in manning levels, etc.

Several preliminary actions have been taken by the separate services. The Air Force Systems Command sponsored the Weapon System Effectiveness Industry Advisory Committee (WSEIAC) Study which provided a framework for system/cost effectiveness analysis. The Army (AMC) has issued AMC Reg. No. 70-28 which establishes an AMC Systems Analysis Center (AMSAC) as well as requiring system analysis on major systems in the concept formulation and definition phases. The Navy meanwhile has favored a slightly different framework for effectiveness analysis.

The Systems Performance Effectiveness Group at the Naval Applied Sciences Laboratory is spearheading the fundamental activity in this area.

The above analysis, critical comment, and recommendations are made to indicate the absence of and need for a positive, consistent single thread assessment criteria for reliability and maintainability analysis and measurement. The DoD should insure sufficient coordination of their functional directives to assure their compatibility, only essential overlap or duplication, and that systems/equipments are covered from feasibility studies to phase out of operations.

The original intent was to recommend changes to existing DoD directives which would assure consistency among the departments; however, the DDRE, I&L dichotomy of directives prohibited this course of action.

Recommendation

It is recommended that OSD issue an instruction requiring consistent assessment of systems/equipments in terms of probability of mission accomplishment (or other appropriate measure of effectiveness) during all phases of its life cycle. (A proposed draft instruction is given in Appendix A.)

RELIABILITY/MAINTAINABILITY PREDICTION TECHNIQUES

Predictions are the only input information available for reliability and maintainability assessment during feasibility and early development. Many vital and far-reaching decisions are made based on comparisons of predicted reliability for future equipments versus achieved reliability for existing equipments. Panel 6 carefully reviewed the state of the reliability and maintainability prediction art to see if available techniques are sufficiently accurate in light of the importance of the decisions which they influence (such as the decision to pursue the development and production of a new system).

Considerable progress has been made in this field in the last few years. Recent improvement actions include the revision of MIL-STD-756 and its associated MIL HANDBOOK 217. These revisions resulted in improvement in the correction for various environments and equipment types (K factors). For the first time, differences in degradation by component type were recognized and the procedures were revised to provide for a more accurate prediction of environmental degradation. A second improvement is the pending publication of MIL HANDBOOK 472--Maintainability Prediction. This Handbook represents the first step toward standardizing maintainability prediction techniques.

In spite of this progress, much work remains to be done. Existing procedures are inadequate in terms of their accuracy and are limited in their application to certain equipment types. Specific areas where improvement is urgently needed are as follows:

1. <u>Reliability and Maintainability during Feasibility</u>

MIL-STD-756 outlines procedures for reliability prediction in the feasibility and design steps of system development. Feasibility prediction is implemented by means of Chart I of the Standard; design prediction by the data base of MIL-HDBK-217A. Neither procedure, in its present state, is adequate for today's needs. The feasibility prediction procedure requires knowledge of active element count and, therefore, cannot be applied until the program approaches the design phase. Further, the method is based on failure rates for average active element groups and, in general, will produce predictions which are optimistic for high power equipment categories, such as radar, and pessimistic for low power categories, such as data processing. The failure to distinguish between high and low failure rate functions also deprives the conceptual phase of early information on potential problem areas. Finally, the

feasibility prediction procedure of Chart I is inconsistent; the predicted reliability can vary considerably depending on the size one chooses for "a functional block." For example, if one divides the equipment into two "blocks," the predicted reliability will differ significantly from that predicted for the same equipment divided into ten blocks. There is inadequate recognition of the effect on reliability of interconnection and packaging.

2. Accuracy of Reliability and Maintainability Predictions

MIL-STD-756 and MIL-HDBK-217A ignore the existence of the degradation due to environments other than electrical and thermal stress and hence result in optimistic estimates of reliability. Various users of this standard are having to develop their own K factors or use other techniques to get realistic predictions. A major effort to correlate predictions, R&D test results and measured reliability with a view to deriving realistic K factors appears warranted. A further deficiency is the fact that the failure rates lump both catastrophic failures and parameter change failures. This lumping process tends not only to reduce precision of prediction, but also to restrict the utility of the data as design guidance criteria. Catastrophic failures are theoretically subject to control through quality control. Drift characteristics may be compensated for through circuit design which establishes level of tolerance to part parameter change. Without a breakout of data on each, catastrophic failure rate versus stress and part parameter change versus time, control procedures cannot be effectively implemented.

3. Keeping Reliability Data Current

The second factor is that the MIL-HDBK is not keeping pace with the state of the art, e. g., integrated circuits are not adequately covered. More emphasis is needed and positive action taken to keep the handbook as current as possible.

4. Inadequate Coverage of Mechanical Equipment

Adequate mechanical and electromechanical equipment prediction techniques are nonexistent. Military documentation has not kept pace with techniques developed and applied by industry. Currently, both MIL-HDBK-217A and MIL-HDBK-472 are inadequate with respect to covering non-electronic equipment. Information on failure rates and failure modes on mechanical equipment is extremely scarce in MIL-HDBK-217A. Likewise, repair time data for mechanical equipment necessary to implement maintainability prediction is totally lacking in MIL-HDBK-472.

5. Maintainability Prediction Data Base

In the area of maintainability prediction, there are four techniques developed and contained in MIL-HDBK-472. The data base upon

which these techniques are based is outdated, the techniques have been developed exclusively in the ground, shipboard, and airborne electronics environment, and thus the techniques can be easily misapplied. There is general agreement that we do not have adequate means for predicting maintainability parameters, and particularly so in the earlier life cycle phases when hardware is not well defined.

6. Prediction of Reliability for "Non-Time Dependent" Devices

MIL-STD-756 and MIL-HDBK-217A do not cover reliability prediction for "non-time dependent" devices. Certain material like missile handling devices, switching equipment,etc., are cyclic in their operation rather than time dependent. For some equipment such as certain missiles, environmental stresses far exceed time as a force influencing failure. New and more accurate reliability prediction techniques for such equipment are needed.

7. Summary

The following summarizes the review of the MIL documents discussed in the paragraphs above.

a. MIL-STD-756A - Reliability Prediction, 15 May 1963. Establishes procedures for predicting the quantitative reliability of aircraft, missiles, satellites, electronics equipment and their subdivisions for the purpose of identifying design problem areas, and for apportionment of reliability requirements, as either the Feasibility Prediction or Design Prediction.

Deficiency: Inadequate in illustrating techniques for handling functional relations of elements comprising a complex system.

b. MIL-HDBK-217A - Reliability Stress and Failure Data for Electronic Equipment, 1 December 1965. Provides guidance for implementation of MIL-STD-756, reliability prediction; presents several reliability prediction techniques, useful at various stages of a program, depending upon available information; identifies uses and limitations of reliability prediction; provides a list of reliability information services where further data may be acquired.

Deficiencies: Very little data on mechanical items, inadequate K factors for various environments.

c. MIL-HDBK-472 - Maintainability Prediction (in print). Gives philosophy of maintainability predication, trade-offs between reliability and maintainability, costs and payoffs of predictions. Provides several maintainability costs and payoffs of predictions. Provides several maintainability prediction procedures.

Deficiencies: Procedures need updating, particularly repair time elements. Procedures applicable to nonelectronic items lacking.

The above list is not intended to be all inclusive but illustrates the fact that additional work is needed.

Recommendations

It is recommended:

1. That the departments and agencies give high priority to the conduct of reliability and maintainability prediction studies assigned by the Reliability and Maintainability Assessment Steering Committee. (See Recommendation under Interservice Coordination.)

2. That the departments intensify efforts to correlate test and field results to orginal predictions and use results to improve prediction techniques.

TEST PROGRAMS AS AN INPUT TO RELIABILITY/MAINTAINABILITY ASSESSMENT

Integrated test programs conducted throughout development and production which attempt to meet the test needs of all disciplines through sharing of test time and test hardware have become a way of life for many major DoD systems. These programs are one of the major sources of input information for the reliability and maintainability assessment program.

Normally, those tests specifically designed for reliability and maintainability demonstration occur late in the development cycle. Thus, if a major gap in the assessment program is to be avoided, maximum utilization of data for reliability and maintainability must be made from other types of tests. Unfortunately, experience indicates that much of this data is wasted from the point of view of reliability and maintainability assessment.

Some of the factors affecting this loss of data are:

1. Reliability and maintainability personnel do not always participate in detailed test planning.

2. Data necessary to the assessment of reliability and maintainability are not recorded; e. g., elapsed run time.

3. Reliability and maintainability personnel and test personnel do not agree in advance on whether or not test is valid for reliability and maintainability purposes and do not agree on the definition of a failure.

Most of these problems can be overcome if adequate coordination exists between reliability and maintainability and test personnel prior to the test. Such coordination should include review of test plans, adequacy of sample sizes, data requirements, agreement on test validity, and definition of failure. Project managers should assure that this coordination takes place.

Reliability demonstration tests are a vital part of the assessment program. Reliability and maintainability demonstration tests are becoming increasingly common as a part of R&D contracts for major systems and equipments and are used to a somewhat lesser degree in production contracts for these same systems. However, reliability and maintainability demonstration tests of smaller items are relatively rare. A sample of 10,000 current contracts administered by DCASR Chicago revealed that only 28 contracts contained reliability demonstration tests.

This represented .28 percent of the number of contracts and 11.7 percent of the dollar value. Increased reliability and maintainability demonstration tests would substantially increase the reliability and maintainability data base and more importantly substantially increase the reliability of delivered hardware.

Recommendations

It is recommended:

1. That as the cognizant department, the Air Force initiate a change to MIL-STD-785 adding a requirement for coordination of non-reliability tests with reliability and maintainability personnel. (A proposed new paragraph is given in Appendix B.)

2. That the Services establish policy requiring increased use of reliability and maintainability demonstration requirements for more types of equipments including reprocurements and replenishment spares.

FIELD DATA FEEDBACK

A major data source for reliability/maintainability assessment is field failure and maintenance information. Panel 6 reviewed the existing data feedback systems with respect to their ability to provide adequate and accurate inputs to reliability/maintainability assessments.

All three services have large reporting systems to provide failure data. (Army-TAERS, Air Force-66-1, Navy-MDC). While there are differences in these systems, they do have several things in common:

1. They all were basically designed for maintenance and supply management and inventory control purposes.

2. None of them are specifically designed to measure reliability and maintainability.

3. Inadequate mechanisms for feeding field data back into design.

4. All result in masses of data fed to a central location.

5. All are dependent upon the motivation of the initiator of the report for their accuracy.

6. All are slow to respond to non-standard data outputs which are often required in reliability and maintainability assessment.

To meet the needs of reliability and maintainability assessment all three departments have resorted to special data collection efforts in high cost complex systems to obtain the necessary reliability and maintainability data. These programs consist of installing additional time meters in fielded equipment when required deploying trained data collectors, and collecting additional elements of time and event oriented data using specially devised data forms. Generally, these programs have been successful but suffer from the obvious disadvantage of relatively high cost. While large projects can easily afford such programs, they cannot effectively be used for all equipments. Thus, some type of large data feedback system will continue to be required.

A problem of this magnitude could not be solved during this conference. However, Panel 6 did arrive at the following conclusions:

1. Without exception, the field data feedback and analysis systems of the departments are not presently providing sufficiently adequate and accurate information for reliability and maintainability assessment.

2. These data systems or their successors should be designed to provide all of the data required for effectiveness assessment to include maintenance management requirements.

3. Field data collection systems should be designed to provide reliability and maintainability data consistent with data collected earlier in the program in order to support a life cycle assessment program.

4. In creating their current data feedback systems, the departments have found it necessary to compromise data requirements for various equipment types in order to meet a standard format goal. Further consolidation with its additional "standardization" is undesirable. If it becomes necessary to further standardize, then such action should proceed along functional lines; e. g., all three services might use similar data systems for aircraft, another system for missiles, etc.

5. The controlled reliability and maintainability monitoring programs provide the most accurate present means of monitoring reliability and maintainability of equipment during service tests and operational use.

6. The overall subject of reliability and maintainability measurement for field data feedback deserves more thorough study. Some of the problems which need answering are:

a. What level of accuracy and adequacy can be expected from "census type" data feedback programs versus detailed feedback using sampling techniques?

b. What effect does use of data by the "chain of command" to assess unit effectiveness have on data accuracy?

c. What are the limits on the amount of data that can be required and still expect reasonable accuracy?

7. Special data collection efforts are normally discontinuous. This results in the following:

a. Valuable information necessary to arrive at proper operational and logistics support decisions is lost;

b. Reliability and maintainability parameters, established during development, cannot be correlated with like parameters assessed from field data during the operational phase;

c. Vital weapon system data for use in follow-on, similar weapon system acquisition efforts is lost.

Recommendations

It is recommended:

1. That the Service conduct a study of its field data feedback system whose objective is to determine those changes necessary to make that system capable of providing all of the data required for effectiveness assessment (to include reliability and maintainability) as well as for maintenance management. This study should be conducted by personnel who are currently not associated with the data feedback system.

2. That OSD sponsor an "in depth" study of the filed data feedback problem which would examine such factors as the relative accuracy of special sampling programs versus "census type" feedback systems, the effect of user motivation and means of improving it, centralized and standardized data systems versus decentralized and specialized systems, etc.

3. That the Services continue their use of special reliability and maintainability monitoring programs, especially during the operational phase.

4. In the interim, that all three departments continue efforts to improve the reliability and maintainability coverage of their respective field data feedback systems with emphasis on accuracy of input data.

RELIABILITY AND MAINTAINABILITY DATA STORAGE AND RETRIEVAL

The storage, retrieval, and distribution of data are activities of prime importance in reliability and maintainability prediction, testing, and demonstration. All assessment is based on data collected from controlled tests or operating experience.

As each of the services developed reliability and maintainability practices, it established data processing methods which best served it in the unique set of conditions affecting its operations. Some use was made of existing data, data collection systems and data processing capabilities in-house. Separate data collection, processing, or utilizations were frequently developed to handle specific programs, weapon systems, or operational requirements. As a result, a large number of separate systems have proliferated, each with its attendant data bank. At present, no system exists to correlate data from one data bank to another.

Some of the types and uses of data sources are described in Appendix C. The listing is not complete, but does serve to indicate the extent of variation between, requirements for, and the uses of data. It is also possible to see in the summary, varied manners of handling, response times, and forms of presentation of retrieved data.

The obvious weakness in the present reliability and maintainability data handling program is the near impossibility to adapt readily the data in one data bank to the needs of somebody to whom it is "foreign." On the other hand, imposition of any set of conditions on one system to conform completely with another would lessen that system's merits for which it was tailored. The time to implement, cost to create, and lack of efficiency of an all-inclusive data processing and utilization method throughout one of the services seem to render this solution unfeasible.

Use can be made by DoD activities of most data now stored or being collected only with an application of effort and ingenuity on the part of knowledgeable analysts. Adjustments of the diversely stored and coded data to a common "cross-talk" may well be possible. With direction from OSD, data could be handled and presented by the several systems in ways which would make the information in each bank readily accessible to all concerned.

Recommendations

It is recommended:

1. For the short term, that OSD prepare, publish, and keep current a Reliability and Maintainability Data Bank Index. This document, preferably in the form of a handbook, would briefly describe all existing reliability and maintainability data storage and retrieval systems, indicate the types of data contained therein and give specifics on how to properly request needed information. (Appendix C represents an initial effort in this regard.)

2. For the long term, that action be taken by the Services under OSD guidance to tie decentralized reliability and maintainability data banks together in a network which would allow rapid interchange of information.

RESEARCH IN AND VALIDATION OF RELIABILITY AND MAINTAINABILITY ASSESSMENT TECHNIQUES

Today's reliability and maintainability assessment programs are conducted using tools and techniques developed in the past several years. Continued improvement in the existing "tools of the trade" as well as the development of new tools are essential if reliability and maintainability assessment programs are to keep pace with advancing technology and management needs. Panel 6 reviewed the reliability and maintainability assessment field and identified a number of areas where research is required. These are as follows:

1. Prediction of Reliability and Maintainability Function

REFERENCES:

a. System Reliability Prediction by Function RADC-TRD-63-300 ARINC Research Corp. (May 1963), (Supplement 1 Mar 1965).

b. System Reliability Prediction by Function RADC-TDR-63-146 Federal Electric Corp. (May 1963).

c. Program to Establish Review Point Criteria for Reliability Monitoring, Hughes Aircraft Co., Publication 52063 (Dec 1964).

d. Maintainability Prediction by Unit Function RADC-TR-65-467 ARINC Research Corp. (Dec 1965).

e. Reliability Prediction for Mechanical and Electromechanical Parts RADC-TDR-64-50, American Power Jet Co.

f. Maintainability Prediction by Function (E. P. Simshauser) - Annals of Reliability and Maintainability, Volume 5, Page 421.

g. Achieving System Effectiveness through Reliability Prediction (COUTINHO-TIGER) - 1966 Review - Annals of Reliability and Maintainability, Volume 5, Page 678.

Reliability and maintainability prediction is required for equipments in the early design stage when information available concerns equipment function rather than part population and stress factors. A study under AF Contract, AF 30(602) . 3387 is developing techniques for predicting avionic equipment reliability in the early design stage. Reference (d) is an interim report on this contract. This study follows up referenced earlier work by ARINC, FED, and Hughes Aircraft. Little similar work has been done on mechanical equipment.

Application of the prediction techniques to equipment which differs in design from those studied is apt to be invalid. More work is required to devise prediction techniques which will have wide applicability in early design work. RADC has pursued work on Reliability Prediction by Function for the past three years. A technique for the ground environment has been developed and has shown high promise in trial applications. It is now being refined and will be available for general use in the latter part of FY 67. Very recent work which demonstrated the feasibility of reliability prediction by function in the airborne environment will serve as the basis of FY 67 work in both the airborne and space environments. Preliminary study of maintainability prediction by function has also shown promise and will be the subject of further study in FY 67.

2. Prediction of Reliability Degradation Due to Storage and Handling

REFERENCE: Dormant Operating and Storage Effects on Electronic Equipment and Part Reliability RADC-TR-65-323.

Too often, there is considerable lapse of time between Government acceptance and field use. Information is needed on the effect of storage and handling on reliability. Studies of shelf life of components and whole equipment is required.

RADC now has under way a study of the effects of dormancy and storage on the reliability of electronic equipment. This study, which is referenced above, is being performed at the request of Ballistic Systems Division and will be completed in the first quarter of FY 67.

3. Demonstration of High Reliability Requirements

High MTBF equipment poses a serious problem in demonstration on a statistically sound basis prior to acceptance. A combination of limited testing and application of analytical techniques may offer a reasonable compromise. Study to develop, validate, and document suitable techniques are necessary.

4. Demonstration of Reliability of "Few of a Kind" Systems

Few of a kind systems present a problem in deriving a statistically sound reliability quantification. In complex systems, interdependence of systems and subsystems is not readily determinable. New techniques are needed.

Methods by which preliminary design assessment (including apportionments) can be improved, should be found and introduced into design development. While current research efforts largely result in unique analytic models applicable to a single system, there are

attempts under way to generalize analytic techniques for much wider application. Further research is needed.

5. Nondestructive Test Techniques as an Assessment Tool

REFERENCES:

a. Proceedings, Tenth National Symposium on Reliability and Quality Control, P. 218 (9 Feb 1964).

b. "Complementary Roles of Destructive and Nondestructive Testing in Development Programs"--Nondestructive Testing XVII No. 2 pp 97-106 (Mar-Apr 1959).

c. International Science and Technology No. 31 (Jul 1964).

d. Proceedings, Eleventh National Symposium on Reliability and Quality Control, pp 202-222 (Jan 1965).

e. Mechanical Signature Analysis, A New Tool for Product Assurance and Early Fault Detection (WEICHBRODT)--Annals of Reliability and Maintainability, Volume 5, page 569.

Nondestructive testing (NDT) is a source of unique reliability data which augments data from destructive and environmental testing.

Nondestructive test analysis is a means of correlating development and production test data.

NDT employing ultrasonics, magnetics, infrared photography, X-ray, eddy current and other "senses" extends investigation beyond natural (human) limits. Research is needed on translation of nondestructive testing results into meaningful reliability assessment data.

6. Physics of Failure as an Assessment Tool

Physics of failure studies are being pursued on many electronic parts and integrated circuits and to a lesser extent, mechanical devices. These studies should be continued and expanded especially on nonelectronic devices. Failure mode and failure mechanism studies are under way which provide a basis for reliability and maintainability assessment for mechanical devices. More research is needed in this area.

7. Improved Maintainability Prediction

REFERENCES:

a. Maritime Administration Maintenance and Reliability Program--Dunlap Associates, Inc., MA-3402 4 Vols. (Mar 1965).

b. Status Reports, ARINC Research Corp. MDCS Data Feedback Analysis for the U. S. Naval Applied Science Lab.--Contract No. N00140-66-X0151.

c. Maintainability Engineering, USAMC/Martin-Orlando.

A great need exists for improvements in failure data collection and analysis to enhance maintainability prediction efforts.

An accurate measurement is needed of time and money expended on maintenance action including measure of active maintenance time, the level of maintenance action, all the costs involved, logistic support and downtime.

> Example: A Maritime Administration Study suggests that "a complete expression of maintenance costs would have to include all categories of expense brought about by the potential and actual occurence of deterioration and failure, . . ."
>
> "Even a proportion of fuel consumption could be attributed to the need for transporting: maintenance machinery, equipment, personnel and parts."

Properly planned preventive maintenance may reduce unscheduled maintenance. Excessive preventive maintenance may increase expense without producing offsetting gains.

8. Reliability and Maintainability Prediction of Mechanical Equipment

Development of procedures for predicting Maintainability of machinery and of whole systems is badly needed. Current and planned RADC work in maintainability prediction by function was mentioned above. Other, directly applicable, current work includes a RADC study of the effects of maintenance personnel on equipment downtime and a Navy (Marine Engineering Lab) study on development of reliability and maintainability functions for a ship propulsion system. More emphasis is needed in this area.

9. Use of Quality Control Data for Assessment

A tremendous volume of quality control data is generated during the production phase which is not generally used in reliability or maintainability assessment. Panel 6 considered this data as a potential source of valuable information on critical component failure rates, early failures and burn-in history. Such test data should be useful in shortening reliability test time. The contractors production repair and rework cycle provides a source for evaluation of equipment reliability. Also, too often problems in the field on reliability can be traced to inadequate quality control. Research into correlations between acceptance rates and reliability characteristics should be fruitful.

10. Reliability Demonstration Using Accelerated Testing

Studies have been made on accelerated testing effects and their correlation with reliability and maintainability characteristics. Continued research is needed in the following areas: design of tests, analysis of test data, formulation of models for prediction, effects of combined environments and methods of applying such combined stresses to provide optimum data within reasonable costs. Furthermore, in the face of newly developed products, such as integrated circuits, continuous research is needed to study how these stresses effect these new devices.

11. Human Aspects of Maintainability and Reliability

REFERENCES:

a. Annals of Reliability and Maintainability, Vol 5, page 112, "Armnet - A Quantitative Approach to Evaluation of Man - Machine System Availability."

b. Annals of Reliability and Maintainability, Vol 5, page 116, "A Methodology to Analyze and Evaluate Critical Human Performance."

c. Annals of Reliability and Maintainability, Vol 5, page 123, "Human Factors and Systems Effectiveness."

Many attempts have been made to evaluate the human variable in the reliability and maintainability equation with some success. The literature leaves much to be desired with the obvious conclusion that continued research is needed into the human factor effect on reliability and maintainability as more sophisticated equipment is fielded.

12. Reliability and Maintainability Trade-off Techniques

REFERENCES:

a. Annals of Reliability and Maintainability, Vol 5, page 182, "Cost Effectiveness Session - Introductory and closing Remarks."

b. Annals of Reliability and Maintainability, Vol 5, page 310, "Reliability and Maintainability Cost Trade-off via Dynamic and Linear Programming."

Reliability and maintainability interests are frequently interrelated creating a need for trade-off studies. The manager confronted with the decision needs a visibility which is not easily providied. He needs an ability to judge the potential improvement of each parameter to determine the relative allocation of resources. Research into possible models to express the impacts of trade-offs in a language clearly understood by the responsible manager is needed. The literature takes full cognizance of the dearth of information in this area.

The above list is not complete, but it does include most of the urgent research needs. Some of these problems are the subject of intensive current research while others have not yet been seriously addressed.

Research efforts are incomplete if the resulting techniques are not validated. Too often, good research efforts fail to result in useful end products because this vital step is slighted or omitted.

Recommendations

It is recommended:

1. That the Services intensify research studies (to include technique validation) in the areas listed above under the guidance of the Reliability and Maintainbility Steering Committee. (See recommendation under Interservice Coordination page.)

2. That OSD establish a line item in the budget structure for "Research and Technique Development for Reliability and Maintainability."

USE OF RELIABILITY AND MAINTAINABILITY ASSESSMENT RESULTS BY MANAGEMENT

The purpose of a reliability and maintainability assessment program is to provide meaningful decision-making tools for efficient project management. Ideally, the decision maker should have available to him the projected impact of available alternatives on reliability and maintainability in a form which will allow him to trade off these parameters against other performance parameters, cost, and schedule. Often in the past, reliability and maintainability programs have failed to provide the decision maker with timely, useful, and adequate information. The result is that in far too many cases reliability and maintainability have come out on the short end in the decision making process. This has not been due to a lack of concern on the part of management. Rather, decision makers, when weighing a subjective opinion that reliability may be adversely affected against a quantified increase in performance or decrease in immediate cost, will normally react in favor of the certain consequence and assume the reliability problem can be overcome.

Panel 6 reviewed this last vital link in the reliability and maintainability assessment program chain to determine what factors cause this lack of effective communication with management and arrived at the following conclusions:

1. Reliability and maintainability assessment inputs to management are not made on a consistent and continuous basis across the life cycle.

2. Too often, reliability and maintainability assessments give a description of the existing situation but do not provide a basis for examining alternate courses of action.

3. Reliability and maintainability assessments seldom provide a means of establishing priorities for corrective action in terms of a meaningful value system.

4. Reliability and maintainability assessment results are rarely in a form which allows quantitative trade-off with other performance parameters; e. g., should additional development effort be expended on improvement in reliability, or would it be better spent on accuracy improvement?

Until the above deficiencies are corrected, reliability and maintainability programs will largely remain outside the main stream of management. Far too often, quantified reliability and maintainability assessments are generated by reliability and maintainability personnel

for consumption by other reliability and maintainability personnel and are regarded as interesting but by no means vital by key decision makers.

Panel 6 concluded that this problem cannot be solved by policy or procedural changes. When the reliability and maintainability assessment programs have matured and can make the proper information available to management, it will be used. Hence, corrective action must take three forms: first, improvement of techniques to make assessment results more valid; second, familiarize management with specialized terminology; and, finally, increased in-house competence in reliability and maintainability assessment. These actions should create the proper environment for an effective dialog between management and reliability and maintainability personnel.

Recommendations

It is recommended:

1. That the Services initiate "cradle to grave" effectiveness assessment programs to provide a consistent basis for trade-offs between reliability and maintainability and other performance parameters. (See recommendation under Consistent Assessment Criteria for Reliability/Maintainability.)

2. That the Services place high priority on the establishment and use of assessment techniques which establish meaningful priorities for corrective action and/or are specifically designed to aid the executive in the decision-making process.

3. That the Services undertake continuing programs to train management personnel at all levels in reliability and maintainability terminology while simultaneously reducing specialized terminology to the minimum.

INTERSERVICE COORDINATION

It was the unanimous judgment of the members of Panel 6 that continued progress in reliability and maintainability assessment can best be served by closer and more formalized coordination among the services. A tri-service committee under the chairmanship of OSD having advisory members from DSA, NSA, NASA, and other interested agencies is vitally needed. This committee would serve a dual purpose of exchanging information among practitioners of the reliability and maintainability art and acting in an advisory capacity to OSD and the departments.

Recommendation

It is recommended that OSD form a Reliability and Maintainability Assessment Steering Committee to exchange information and to advise OSD and the departments regarding reliability and maintainability assessment. Specific areas addressed by this committee should include the following:

1. Reliability and maintainability technique research and validation--determine needs, recommend priorities, avoid duplication, and disseminate results.

2. Reliability and maintainability methodology and terminology--assure uniformity, recommend changes, and disseminate information.

3. System effectiveness data system design to insure consistency and continuity throughout all system life cycle phases.

Appendix A

PROPOSED DEPARTMENT OF DEFENSE INSTRUCTION

SUBJECT: Life Cycle Assessment of Materiel Effectiveness

References: (a) DoD Instruction 3200.6, "Reporting of Research and Engineering Program Information."

(b) DoD Direction 3200.9, "Initiation of Engineering and and Operational System Development."

(c) DoD Directive 4100.35, "Development for Integrated Logistic Support for Systems and Equipment."

(d) DoD Directive 4155.11, "Improved Management for Quality and Reliability Assurance of Materiel."

I. PURPOSE

This Directive establishes DoD policies and objectives governing the life cycle analysis and assessment of materiel effectiveness to assure mission accomplishment, assigns responsibilities and directs appropriate actions for carrying out the program.

II. APPLICABILITY

The provisions of this Directive apply to the Departments of the Army, Navy, and Air Force, and the Defense Supply Agency.

III. DEFINITIONS

For purpose of this Directive, definition of terms not defined herein are in accordance with MIL-STD-280 and MIL-STD-721B.

A. ASSESSMENT--The quantitative determination of predicted or observed performance of materiel against pre-established effectiveness criteria.

IV. CONCEPT AND OBJECTIVES

A. The primary objective of life cycle assessment is to provide management with continuous information reflecting reliability and maintainability status in the context of materiel effectiveness. This assessment is based on a concept of establishing criteria for measurement of materiel effectiveness at the outset of a program. These criteria are then held constant from

the initiation of engineering development through deployment and subsequent reprocurements.

B. The overall objectives of the DoD Assessment Program are:

1. To provide a quantitative measure of Materiel Effectiveness.

2. Provide consistent and compatible criteria for logistic support of systems and equipment.

3. Provide a means by which the Departments can make effective trade-offs and take timely action for improvement.

V. RESPONSIBILITIES

The ASD-( )[1] will provide overall policy guidance for the systems/equipment assessment program and shall monitor its implementation to assure attainment of the objectives outlined in the above.

VI. MANAGEMENT ACTIONS

The Departments will:

A. Establish procedures that assure life cycle assessment of major systems and equipment.

B. Utilize formal modeling and statistical methodology in the assessment and prediction of systems/equipment effectiveness.

C. Provide for the orderly transition of data throughout each phase of a systems/equipment life cycle.

D. Insure the inclusion of Quantitative Reliability and Maintainability requirements in all system/equipment contracts including rebuys.

E. Perform early assessments of fundamental requirements documents to determine feasibility of achieving stated reliability and maintainability requirements.

F. Maintain and insure adequate, compatible data feedback to support the assessment.

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[1]The appropriate organization to be designated by OSD.

G. Establish procedures which provide for timely availability and maximum utilization of assessment results at all levels of DoD.

H. Develop figures of merit by which system/equipments can be compared within common environments.

I. Perform these assessments as objectively as practicable. In-house assessments should be performed to the extent possible within manpower restrictions. If this is not practical, a "third party" contractor (not hardware oriented) should be used. If it is necessary to have assessments performed by prime contractors they will be reviewed, monitored and approved by knowledgeable in-house personnel.

VII. This Directive is effective immediately.

Appendix B

PROPOSED ADDITION TO MIL-STD-785

5.1.4[1] Coordination of Test Requirements and Test Plans. Reliability data requirements shall be integrated into all types of tests such as proof of design, breadboard, prototype, environmental, production and acceptance. In order to achieve this, sample sizes, data requirements, definitions of failure, and special instrumentation requirements shall be coordinated with those primarily responsible prior to the conduct of test.

[1]Subsequent paragraphs should be renumbered.

Appendix C

RELIABILITY AND MAINTAINABILITY DATA STORAGE AND RETRIEVAL SYSTEMS

Some of the types of data storage and retrieval systems now in operation within DoD and NASA are briefly described in this appendix.

FARADA--FAilure RAte DAta

Navy Weapons Command established the FARADA program (for Fleet Ballistic Missile Program) to collect, summarize, analyze, compile, and distribute failure rate data. Close to one hundred organizations and facilities participate in this program. The failure rate data initially contributed by the participants was compiled as the "Failure Rate Data Handbook," SP 63-470, which was distributed in June 1962; the volumes (2) are updated quarterly.

Volume I presents tabulated data divided into the following sections: Electrical, Electronic, Mechanical, Hydraulic, Pneumatic, Prototechnic, and Miscellaneous.

Volume II presents stress curve data including source "Background Information" to provide the required degree of validity and applicability for the Volume I data.

The tabulated data uses computer storage, manipulation, and retrieval techniques. FARADA is at present being supported by the three departments and NASA.

IDEP--Interservice Data Exchange Program

This program, sponsored jointly by the three departments, provides for the interchange of reliability test data on missile and aerospace components and parts. The charter of IDEP, as presently set up, allows participation only by prime contractors (and major subcontractors on certain programs) engaged in ballistic missile and space hardware projects for: The Air Force Ballistic Systems Division, Space Systems Division, The Army Missile Command, or the Navy Special Projects Office.

To utilize IDEP, a contractor mails a summary sheet and two copies of his report to the data distribution center of the cognizant

service. The center microfilms the entire report and adds a summary, based upon that accompanying the report from the contractor, to a microfilm card. The only alterations made in submitted material are those that may be necessary to comply with standard formats. The film-card combinations are then mailed to all contractors interested in the topic on a monthly basis.

The processing of the data into historical data files provides up-to-date reliability performance criteria that are especially useful when the files are subsequently used as the data source for a reliability prediction and analysis program.

ECRC--Electronic Component Reliability Center

The Electronic Component Reliability Center (ECRC) was intended at Battelle Memorial Institute, Columbus, Ohio, on 1 March 1959. Beginning with eight industrial sponsors, its membership has now grown to include Government agencies. The Center is supported through individual contracts with Battelle, and are renewed each year.

The objects of the ECRC program are: the extraction of reliability information from sponsor data, development of techniques for reliability analysis, and assisting members in the application of those techniques.

The ECRC Data Center, therefore, is a clearing house for all available information about the types and performance characteristics of electronic parts of particular interest to its members. The various data outputs are as follows:

1. Data Summaries--data from test reports received from the members.

2. A Unified Index which lists all reports from members with a code that indicates the location of additional report information of special interest.

3. Technical Memoranda--describe the effects of particular environments on various part types, and also give special listings of pertinent information.

4. Special Services which provide individual members with answers or information about particular devices.

PRINCE--Parts Reliability Information Center

PRINCE is a specialized data center developed and maintained by the NASA George C. Marshall Space Flight Center (MSFC). The PRINCE provides an automated data storage and retrieval system that contains technical information useful in a parts reliability program; it includes over 20,000 test reports on 16,000 individual parts.

Maximum use is made of other parts-data centers such as IDEP (Interservice Data Exchange Program) and ECRC (Electronic Component Reliability Center) at Battelle Memorial Institute. In addition to these sources, a great deal of information comes from MSFC and other NASA centers and contractors.

NEDL--Naval Electronic Data Library

The Naval Electronic Data Library (NEDL) documents the electrical and physical descriptions of all Naval electronic equipments from the system level down through the functional circuit level. This data library is being used to provide detailed functional studies for each of the systems documented, and assists in determining the number and types of high usage functions that are required in each system. Included in this library are such additional details as cost, reliability, MTTR, physical size, and weight.

The control center for this library is located at the Institute of Cooperative Research, University of Pennsylvania, Philadelphia, Pensylvania, whose mission it is to continually update the library with the latest system developments, and to provide information processing services for its users.

Reliability Central (Rome Air Development Center)

The development and establishment of a "Reliability Central" at Rome Air Development Center is now under way. The Central will serve as the Air Force focal point for the acquisition, storage, analysis, and dissemination of reliability information. Initially, the Central's operation will be limited to electronic part types covered by Federal Stock Class 59. Eventually, the operation will encompass semiconductor integrated circuits, mechanical and electromechanical parts, equipment, subsystems and systems. (Prior to the establishment of a full-scale Central, a test operation on transistors and diodes will be developed and implemented to demonstrate the feasibility and potential

of a full-scale system....) The expansion of the Central's file to incorporate reliability information on equipment, systems, and mechanical parts and assemblies will be accomplished in an orderly manner.

FMSAEG--Fleet Missile System Analysis and Evaluation Group

FMSAEG has an integrated program for the collection, processing, and analysis of reliability, operability, and component part-failure data for surface-missile systems. While the major portion of the data collection function will be replaced by the MDC system, the FMSAEG processing and analysis will continue. During the transition period, both FMSAEG and MDC systems will be used.

FMSAEG has the following three principal areas of analysis:

1. Surface-missile flight analysis--firing reports, telemetry records, and flight-test scoring.

2. Surface-missile test equipment and missile checkout experience--failure rate tabulations of missile modules and checkout equipment.

3. Analysis and summarization of certain fleet equipment data to yield measures of average up time in various operating states. This type of analysis produces a gross measure of readiness.

MDC--Maintenance Data Collection System

MDC has been designed as a uniform, Navy-wide failure data reporting system. Data collection, purification, and processing MDC (implemented in 1965) is performed by the Maintenance Support Office (MSO), Mechanicsburg, Pennsylvania.

MDC data outputs mainly consist of general and summary data runs; more elaborate data runs and analyses will be performed by the interested bureaus, laboratories, and other agencies which utilize the basic data. The prime BUWEPS Agency operated by the Armament Maintenance Management Information Center, Naval Weapon Station, Concord, California, will be responsible for ship data. Air data will be handled by the Naval Air Technical Services Facility, Philadelphia, Pennsylvania.

66-1 MAINTENANCE DATA COLLECTION SYSTEM

The Air Force Maintenance Data Collection System as described in AFM 66-1 provides the necessary information with which to manage base level maintenance. Additionally, this information is being used in reliability, maintainability, spares provisioning, etc., on operational system or equipments. Data collection is at the base (flight line and shops) level. It is forwarded to HQ, AFLC, Wright-Patterson Air Force Base, Ohio, Where it is processed.

AFM 66-1 data outputs are available to interested commands and contractors. It consists of general and summary products with special purpose products available on request. Raw data, processed to magnetic tape, is made available to subcommands of AFLC for detail reliability and maintainability analysis.

THE ARMY EQUIPMENT REPORTING SYSTEM

TAERS

Maintenance data are collected from users of Army equipment, summarized and analyzed. Data elements are identified in computerized form permitting rapid feedback to users of these data. Additionally, TAERS provides for the submission of Equipment Improvement Reports which are furnished to Army design and development activities. The TAERS Data Central is located at Lexington, Ky., under the direction of the Army Maintenance Board. Each commodity command of the Army Materiel Command has computer facilities to handle the tapes furnished by the Data Central and print out pertinent information needed to support the assigned maintenance mission.

ADRES--Army Data Retrieval Engineering System

Engineering data, such as standard and commercial drawings, specifications, standards, and package data sheets, can be automatically retrieved from this data bank. It contains over 200,000 documents and is drawn on by 15 industry contractors and 60 in-house stations. The data comes from in-house Army sources and is stored in microfilm cartridges. The output forms are either visual displays or hard copies.

The data is obtainable in approximately one week, if it is in-house, or in three to four weeks if it must be accumulated.

MEDAL - Micro Miniaturized Engineering Data for Automated Logistics

This data bank contains engineering drawings of interest to the U. S. Air Force. There are over 6 million drawings on file.

The bank is used primarily by Air Force in-house agencies, and it processes more than 1,000,000 data requests per month. The data is obtained from Air Force contractors and is stored in aperture cards. The information output of this system is in the form of aperture cards and hard copies.

EDS-0009 - Engineering Data System-0009

This data system is a breadboard model of an automatic storage and retrieval system for engineering information. It contains configuration, test, maintainability, and reliability data, and package data sheets for standardization. At present, the data bank has engineering information on 15,000 capacitors, 15,000 relays, 8,000 metals, and 1,000 other materials. The data has been accumulated from Federal and international agencies, including NATO industry. These data suppliers are also the primary customers. Information is stored on microfilm cartridges and magnetic tape. Outputs are in the form of hard copies, facsimiles, and visual displays.

REPORT OF PANEL 7

TITLE: Personnel and Training

OBJECTIVE:

To recommend plicies, procedures and actions essential to insuring qualified personnel for the management and implementation of quality and reliability operations.

TOPICS DISCUSSED:

1. The Diagnosis of the Personnel and Training Problem as it Relates to Quality and Reliability in the DoD.

2. A Total Quality and Reliability Career Program.

3. Acquisition. Development and Retention of Quality and Reliability Skills.

PARTICIPANTS

Chairman	Mr. A. Lynn Bryant, Army Management Training Agency
Panelists	Lt. Col. Warren R. Aiken, USAF, Air Training Command
	Mr. John E. Tolnitch, HQS, AFSC
	Mr. J. P. Grisez, HQS, FAA
	Mr. Lou Korn, SUPSHIPS Groton Conn.
	Mr. Emil Marchio, Jr., NAVAIRREADREP Central
	Mr. T. M. Vining, HQS, DCAS
	Mr. T. Weinstein, HQS, DSA
	Mr. Daniel E. Negola, HQS, NASA
	Mr. Miles R. Hardenburgh, Army Missile Command
	Mr. Cornelius J. Brown, HQS, FSS, GSA
Recorder	Mr. Eugene Newnam Army Management Engineering Training Agency
Monitor	Mr. Glenn J. Soares, HQS, DCAS

THE DIAGNOSIS OF THE PERSONNEL AND TRAINING PROBLEM AS IT RELATES TO QUALITY AND RELIABILITY IN DoD

There are approximately 15,000 personnel in the DoD currently engaged in quality and reliability assurance activities. These people are professionals and sub professionals employed throughout the logistics spectrum from research through standardization and maintenance. The bulk of these people are engaged in the procurement segment of the spectrum where inspection and quality assurance have traditionally been utilized. In spite of this latter fact, quality audits by the military services of the material in their Depots have indicated a distressingly high percentage of non-conforming material.

In addition, personnel engaged in procurement quality assurance continually complain of weak or missing quality assurance criteria and requirements in contracts and weak or missing quality assurance elements in specification. These latter facts are testimony to the ineffective performance of quality assurance personnel in the pre-procurement segment of the logistics sequence such as research, development and engineering.

Similar effects of non-performance or weak performance can be assembled concerning the segments of the logistics sequence beyond procurement such as storage, maintenance and rework. In effect, the above constitutes an indictment of the management and application of these 15,000 personnel in DoD. In fact, it must be admitted that we do not seem to be efficiently and effectively utilizing and managing these skills which we must admit are extremely important to the delivery of the necessary quality and reliability to the military user.

When Panel 7 assembled to discuss the problem and make recommendations concerning improved career management and training of its personnel engaged in quality and reliability assurance, it found itself unable to come to grips with the problem. Discussed were known weaknesses in current training programs such as the apparent training for training's sake, but it was recognized that this was not the basic problem, but merely the symptom of a larger problem.

It soon became apparent that the larger problem was the fact that the important expensive quality and reliability assurance program did not exist as a program. Personnel engaged in the activities include engineers, statisticians, quality managers, specialized technical skills, specialized commodity skills, all held together in loose-knit arrangement by a thread of quality assurance techniques.

Problems were found in the incorporation of the special professional skills of engineering, science and mathematics into the general structure of quality and reliability because of the lack of a professional image. Many "spot management" programs and other activities were generated in reaction to serious but limited problems. We found these good, little, quality and reliability management programs working with varying degrees of integration within services, very little integration between services, and no major discoverable management guidance from OSD. Two points seemed to be the heart of the problem, these being no quality and reliability assurance program identification and no overall management or recognition.

Examples of good but relatively unintegrated spot management programs are the special treatments found necessary by Admiral Rickover to achieve the ends he desired and the special treatment that NASA receives through specific direction by agreement with the Secretary of Defense. There are many lesser examples throughout the DoD structure.

It was deduced that one of the problems of acquisition and retention of professional skills today appeared to be the inability to integrate these skills and professions effectively into one segment of the logistics spectrum with almost no ability to apply them on a balanced basis in the several segments where they can be most effectively utilized.

For example, it is conjectured that more application of quality and reliability assurance skills in pre-procurement activities would permit the use of fewer and lower skills in procurement and the ensuing logistics segments. Too often, today, we are using high skills in procurement quality and reliability assurance in order to detect weaknesses which should have been prevented during earlier activities.

This important consideration cannot happen effectively today because the pre-procurement segment falls under another element of DoD cognizance.

Summary

The diagnosis of the Panel is that there is no quality and reliability program as such and as a result we are dissipating important talents and in effect, not managing the application of these important skills.

A TOTAL QUALITY AND RELIABILITY CAREER PROGRAM

There is a lack of clearly defined and integraded quality and reliability career development programs within the DoD. A series of interfacing, carefully structured programs designed to provide for continuity of purpose for total product effectiveness is required as follows:

1. Functional areas need to be identified and relevant skill steps and levels established.

2. There exists among project and program managers an indifference to quality and reliability which must be overcome.

3. Quality and reliability milestones must be incorporated into formal systems of management control.

4. There exists an inequality, both in organizational placement and salary, between quality and reliability and other major programs which must be reconciled.

5. Developmental guidelines to assist individulas toward a variety of required combinations of disciplines, management and technical areas must be prepared.

6. There is a critical shortage of qualified personnel due to such factors as expansion, changing technology, attrition and the fact that our educational institutions and service schools are not geared to meet our requirements.

7. Currently, limited ceilings and operational billets preclude long range career development.

No question has aroused more interest and discussion that that of: What would be the appropriate job series of DoD civilians engaged in quality and reliability work? The concept of a single series was analyzed and even though this concept does have merit, it was concluded that a single series would be restrictive to a point of limiting the ability to recruit, train and retain the types of skills required to perform the many and varied functions of product effectiveness.

The four job series presently used are: 1900, 1500, 1300 and 800. The preponderance of people in product effectiveness activities are in the 1900 series. This series initially was established to accommodate traditional quality control. Today, it is being given much broader application. Many of the people in management positions in quality and

reliability are in the 800 series and this trend is increasing. This often causes a very capable employee in either the 1300, 1500, or 1900 series to find that their career is blocked.

It is proposed that in addition to the four series that are currently used, the 340 series be used to describe the functions of the quality and reliability manager. Employing this series would bridge the gap between the professional and non-professional groups and also would have the very desirable advantage of affording all capable individuals an equal opportunity for top management positions. Predominantly, our 800, 1300 and 1500 peopl would contribute to complex system planning and product design during the conceptual and definition phase. Our 1900 people predominantly would contribute to the assessment function so vital to production, maintenance and field operations.

DoD liaison with various educational institutions should provide curricula guidelines for the preparation of graduates to enter the product effectiveness program. This liaison to include coordination and establishment of academic minimums as pre-requisites to entering the product effectiveness career field, a program of education for the educators in the area of quality and reliability, a coordinated program with the professional and industrial community, and an evaluation medium whereby requirements data feedback could be obtained for appraisal and improvement of the academic environment.

Quality and reliability programs of a career nature suitable to all DoD and NASA personnel exist at the USAMETA, The Air Force School of Systems and Logistics and to some degree at the USALMC. At the present time, the Air Force Institute of Technology 18 month program leading to a Master of Science Degree in Reliability Engineering is the only course of its type available. The shortage of persons with specialized knowledge in the quality and reliability fields will not be relieved through forthcoming college graduates since only a very few educational institutions provide training specializing in quality and reliability engineering as a part of their curricula. Quality and Reliability Engineers are for the most part, self taught; in fact, few university professors are qualified to teach reliability, hence a need for educating educators.

Of vital importance is that part of the career pattern which includes cross-fertilization. Specifically, since the Product Effectiveness Program spans the entire life cycle, it is vital that quality and reliability managers have experience in the research and development, procurement and maintenance program phase. In addition to in-house cross-fertilization, tours of duty in industrial organizations should be arranged

and pursued. Conversely, it is believed desirable that industrialists with whom we do contract business be brought into the military environment as a part of our cross-fertilization effort.

Establishment of a professional requirements board is a must; this board to be composed jointly of military and civilian personnel concerned with professionalism requirements at each level of all phases of the career program. This would provide a basis for a sound training curricula as well as standardized qualification and selection criteria. This is consonant with the efforts of many of our technical societies moving toward a professional certification program in the field.

Today, in our service schools, there are many splinter courses of instruction given for reliability and quality. There is not, at this time, a single school that teaches an integrated course covering all facets of the Product Effectiveness program. It is highly desirable that a survey be conducted of the courses available today with an objective of consolidating where practical and eliminating duplication.

Recommendations

It is recommended:

1. That the OSD recognize the need for and accept the responsibility for directing the establishment of quality and reliability assurance as a program with identification and entity applicable across the entire logistics spectrum, as well as establishing a structure for its effective focal management.

2. That a study be directed which will concisely identify and describe the total product effectiveness program, the role it must play throughout the spectrum, as well as the several professional and subprofessional skills required. This study, in addition to necessary identification, should also result in recommended DoD Directive material and appropriate modifications to existing directive material (ASPR, DoD Directives, etc.).

3. That a career program structure be developed which will incorporate as part of its structure the several professions and skills, facilitate their proper application and permit movement and growth of military and civilian personnel horizontally and vertically in the career ladders necessary to attraction and retention of the calibre of personnel necessary would result. As a part of the career program, mandatory assignment rotation both geographically and in specialized fields would help assure that a sufficient number of people with board experience

could rise to the levels of mid and top management necessary to the broad guage concepts of the program. In the development of a career program for product effectiveness personnel, provisions be made for the transition from the 800, 1300, 1500 or 1900 series into the 340 or other appropriate series, in order that any member of the product effectiveness team has a defined career progression to top management positions.

4. That increased liaison be maintained with educational institutions for the purpose of developing prerequisite material necessary to preparing college graduates for entry into the product effectiveness career field.

5. That increased educational opportunity for selected personnel to include such things as scholarships and grants for advanced study, tuitional assistance, job absence permissiveness for apprentices, upgrad and graduate work for journeyman and comprehensive, self-development program for enrollees in the career field be provided.

6. That in-service and specialized training for career progression be made mandatory and be incorporated. Here particular emphasis would be placed on quality and reliability technical know-how, enhancing of the management ability of the individual exposure to peripheral systems such as pricing, contracting legal aspects, work measurement, budgeting, system analysis, etc., and where applicable, comprehensive structured on-the-job training.

7. That specific DoD-wide training agreements be developed to attract suitable college talent and retain them in the quality and reliability management function by providing them with an organized plan of training and development which would include: training given throughout the career cycle which addresses itself to specific courses in technology, techniques and methodology contingent upon the immediate assignment of the individual and his long range objectives.

ACQUISITION, DEVELOPMENT AND RETENTION OF QUALITY AND RELIABILITY SKILLS

Approximately three fourths of the personnel engaged in product effectiveness activities will likely be lost through attrition within the next ten years. Sources of input to replace these losses are limited especially in the engineering and management field. There is a lack of functional definition within the career field and an absence of a clearly defined career development program attractive to high potential input. In addition, the Federal Government is not competitive monetarily in the scientific and professional career fields insofar as the recruitment of the young college graduate/potential manager is concerned.

As a result of the careful definition of the role of quality and reliability, it will be necessary to investigate the current status of skill availability and compare this with the requirements as defined. Voids or overages discovered can then be resolved. Positive steps can be taken to fill the voids through such means as retraining personnel found to be in oversupply, selective hiring, cross training of individuals already engaged in product effectiveness activities, or through the assignment of military personnel with appropriate skills.

Institutional education, such as colleges and universities lags some ten years behind demands of present-day technology insofar as product effectiveness is concerned. A study conducted by Catherine Hock, entitled "Reliability Engineering Education at Colleges and Universities",[1] along with a survey made by Dr. Dimitri Kececioglu and Mr. Joe McKinley of the University of Arizona entitled, "Reliability Engineering Education Activities in the United States and Overseas", [2] bears this out. For example, the Hock study reveals that approximately 205 accredited colleges and universities give degrees in engineering. Of these, 38 give one or more courses covering some phase of reliability. However, it was of particular concern to note that of the 92% of the engineering schools offering statistics, only 2% or four (4) of the universities require it for an engineering degree. It was also revealed that almost all reliability courses were, in reality, only courses in statistics. This

[1] "Reliability Engineering Education at Colleges and Universities", Catherine Hock, Office, Manned Space Flight, NASA, Washington, D.C.

[2] "Reliability Engineering Education Activities in the United States and Overseas", Dr. Dimitri Kececioglu, Prof. Aerospace and Mechanical Engineering and Joe McKinley, Graduate Associate in Research and Teaching, The University of Arizona.

was true in both the graduate and undergraduate programs. The University of Arizona study shows that in addition to the shortcomings of the engineering curricula, there is a lack of coordinated short courses, symposia and conferences of a general interest nature. For the most part, they are highly specialized for a particular weapon system or piece of hardware.

The few quality and reliability courses tailored to appeal to the Defense establishment, such as the 18 month program in Reliability Engineering conducted by the Air Force Institute of Technology leading to a Master's Degree in Reliability Engineering and the variety of joint DoD short courses in Quality and Reliability presented by the U. S. Army Management Engineering Training Agency, the Air Force School of Systems and Logistics and the Army Logistics Management Center, do not satisfy all of the existing need, although in many cases classes go unfilled. Again, the fact that all of the needs are not met is due in part to the fact that many of the needs are not known or defined.

It is obvious, that until such time as university curricula fully prepare graduates for the job of product effectiveness, that a continuing need will exist for in-house career development and training. A second need in this regard is the requirement to train educators to educate. At the present time, the only such program known is one at the Universith of Arizona conducted under the sponsorship of the National Science Foundation, which is designed exclusively to train university professors in the tools, techniques and methods of presentation of the concepts of quality and reliability in order that they might more effectively incorporate these ideas into their own curricula.

Another finding as a result of panel investigation showed that not only are a majority of individuals considered knowledgeable and experienced in product effectiveness about to retire, but that many of them are assigned to functions which do not adequately utilize this presently available knowledge and experience.

In order to assure fully staffed positions requiring product effectiveness skills, it is necessary to acquire "new blood" immediately; but in order to do this, the positions must be made attractive both monetarily and from a career development viewpoint. The functions to be performed must be clearly defined in order to retain the individuals; and a program, both formal and informal, must be established whereby the individual is able to constantly grow.

An intensive campaign is required to educate industry and educational institutions to understand the important positive role that product effectiveness plays in producing a trouble free product.

Recommendations

It is recommended:

1. That OSD designate an Executive Agent within DoD to:

a. Provide a focal point for the research, development and monitorship of programs of instruction in the quality and reliability area.

b. Analyze the capability of existing quality and reliability skills in relation to current occupational requirements and qualification standards.

c. Designate a task group composed of representatives from the military services and the Defense Supply Agency to structure a career development program for product effectiveness; engineers, technicians and managers.

d. Examine existing programs of instruction in service schools, academic and industrial facilities to establish comprehensive plans for the systematic development of all product effectiveness personnel.

e. Since individuals associated with product effectiveness should be experienced across the entire logistics spectrum.

f. Encourage greater joint use of DoD Service schools.

g. Extend blocks of instruction in quality and reliability into the Senior Level Service Schools and Staff Colleges, ICAF, War College, etc. to give management appreciation of the quality and reliability role in DoD structure.

h. Establish graduate level programs of instruction which will permit the training of professional and engineering personnel in specialization of quality and reliability fields.

i. Modify and extend the technical short courses in the quality and reliability field to provide across the board training of technical and managerial personnel in Product Effectiveness.

2. That Military personnel who have received and are receiving specialized training in product disciplines be identified through some designator in order that they might provide a reservoir for future assignments which could take advantage of their experience.

REPORT OF PANEL 8

TITLE: Metrology and Calibration in Quality and Reliability Operations

OBJECTIVE:

To recommend action required for the effective integration and utilization of metrology and calibration in quality and reliability operations.

TOPICS DISCUSSED:

1. Identification of New Measurement and Calibration Requirements

2. Selection of Proper Test and Inspection Equipment and Measurement Processes

3. Promulgation of Uniform Specifications Controlling Contractors' Calibration Systems

4. Provision of Metrology Support to Contract Administration Personnel

5. Establishment of a Central Point of Contact within Office Secretary of Defense Responsible for Overall Policy for Metrology and Calibration and for Coordination with Other Government Agencies

PARTICIPANTS

Chairman	Mr. Jerry L. Hayes, Navy Metrology Engineering Center
Panelists	Lt. Col. Gail D. Conlee, USAF, HQS Air Force
	Mr. Ray Y. Bailey, Newark Air Force Station, Ohio
	Mr. L. Weissenberger, FAA Depot, Oklahoma City
	Captain R. H. Gillock, USN, Fleet Readiness Rep, Atlantic
	Mr. Ernie D. Stefani, DCASR, Detroit
	Mr. Richard J. Bedford, HQS, DCASR
	Major William A. Porter, HQS, NASA
	Mr. David M. Herzmark, White Sands Missile Range
	Mr. Melvin Fruechtenicht, Army Metrology and Calibration Center
	Mr. J. M. Cameron, HQS NBS
	Dr. George E. Schafer, NBS, Boulder
Recorder	Mr. David W. Worden, Navy Metrology Engineering Center
Monitor	Mr. S. G. Hamner, HQS Naval Material Command

IDENTIFICATION OF NEW MEASUREMENT AND CALIBRATION REQUIREMENTS

Identification of new systems measurement requirements which are beyond the current state-of-the-art must be accomplished as early as possible in the materiel life cycle, preferably in the concept stage, to permit maximum lead time for development of supporting standards and instrumentation. Normally the systems development contractor is in the best position to identify and analyze such requirements.

The services and NASA have used several approaches to the problem of early identification of new measurement requirements with varying degrees of success. Documents such as MIL-Q-9858A (DoD), Quality Program Requirements; MIL-D-9412D (USAF), Data for Aerospace Ground Equipment; and MIL-Q-21549B (WEP), Product Quality Program Requirements for Fleet Ballistic Missile Weapon System Contractors, contain general requirements. More specific requirements have been outlined in special contract provisions; however, there is no uniform method for submission of such data prescribed by directive or ASPR.

The nature of system development is such that priority of engineering effort is normally directed at development of operational hardware. Consideration for reproducible measurements that will be required to support development and testing is often overlooked until a crisis arises in connection with compatibility of test data.

The forecast of such measurement requirements may require research or development action by the National Bureau of Standards to establish an appropriate national standard. Also, it will afford time to develop test equipment to measure the necessary parameters on a production basis, which is necessary to the successful production of state-of-the-art components. A hasty selection of inappropriate equipment could thereby be avoided.

A complete review of the specifications and contract clauses now included in systems development contracts within DoD is necessary to determine whether new contract language or a revision to existing military specifications is needed. The revision or expansion of MIL-D-9412D (Air Force) to make it applicable to the collection of state-of-the-art measurement requirement data as well as systems calibration requirements information is a possible solution.

Experience has shown that, regardless of contract method, the forecast of new measurement requirements is difficult to achieve and

often delayed. While the identification of metrology problems to NBS and the service metrology centers has been accomplished by rather informal methods, the concern here is with early, and perhaps more formal identification, so that the lack of ability to measure does not become a deterrent to technological progress or the excuse for lack of ability to determine quality.

Recommendation

It is recommended that DoD prepare contract language and/or a military specification to require systems development contractors to identify, analyze, and advise the metrology engineering centers, through the contracting officers, of potential new state-of-the-art measurement problems early in the development phase of the materiel.

SELECTION OF PROPER TEST AND INSPECTION EQUIPMENT AND MEASUREMENT PROCESSES

Inadequate emphasis is being placed on the proper selection and support of test and measuring equipment in research, development, design, production, quality control, and operation and maintenance stages and in monitoring the adequacy of test equipment and its usage in research and development activities.

The literature and technology of instrumentation is widely scattered and difficult to research; hence, the selection of instruments and the techniques for their application are equally difficult. Measurement needs are frequently overwhelmed by "gold plating" or are only partially satisfied. There is a need for the generation and publication of technical guidance to provide assistance for optimizing equipment selection.

Developers, development agencies, and commodity managers, in their zeal to deploy military equipment to meet requirement schedules all too frequently fail to avail themselves of the metrology competence of standards and calibration laboratory personnel and similar specialists in the selection of test and measuring instruments for the field. This has frequently resulted in the fielding of expensive, overly precise, or overly accurate test and measuring instruments.

The losses due to unreliable measuring instruments are inestimable. DoD decision makers must have reliable, accurate data on which to base their conclusions and recommendations. The final data obtained by testing assembled hardware must be sufficiently consistent and repeatable to prove the confidence level of reliability estimates. This can only be achieved through provision of effective equipment, measurement techniques, and data feedback systems.

Recommendations

It is recommended:

1. That DoD generate and publish a technical guide for use by Government and contractor engineering personnel to aid in selecting test and inspection equipment. The guide should emphasize and/or require the use of metrology and calibration personnel to aid Government and contractor research and design engineering personnel in test equipment selection.

2. That a requirement be placed in individual service regulations or existing regulations to ensure that the test and measureing instruments of research and development activities will be subjected to the same quality control measures as are those in other phases of the materiel life cycle.

3. That DoD revise appropriate military specifications to require controls over the selection, performance, and application of test equipment in DoD contracts.

4. That DoD develop a training course for engineering and contract administration personnel in the selection and application of test and measuring equipment.

PROMULGATION OF UNIFORM SPECIFICATIONS CONTROLLING CONTRACTORS' CALIBRATION SYSTEMS

Specifications often referenced or required by contracts that delineate calibration requirements are: MIL-Q-9858A, MIL-I-45208A, MIL-C-45662A, MIL-C-55163 (Sig. C), MIL-Q-21549B (WEP), NASA NPC-200-1A, NASA NPC-200-2, MIL-I-45607, MIL-I-8500B and MIL-Handbook 50, 51 and 52. These specifications differ as to the extent of the requirements for calibration and measurements.

As examples of confusion created, some specifications require adherence to a strict 10 to 1 accuracy ratio, while others make no reference to such ratios. Some specifications are not clear as to the requirements for recording results of calibration. Other specifications allude to the requirements for a mandatory recall system whereas still others are specific.

Due to the problems created, Government contract evaluation agencies find it difficult to enforce and administer contractual provisions as envisioned by the procuring agencies.

It is important that NASA and DoD calibration system requirements be consolidated into one specification. Many R&D contracts, particularly those which are for research studies or do not require fabrication of hardware, do not require control of measuring and test equipment. In many of these contracts, measurement data represent the product, and control of these data is essential.

There are measurements being made of physical or material phenomena by R&D contractors which must be supported by measuring equipment of known accuracies. In many of these contracts, measurement data represent the product and control of this product's quality is essential. In addition, some small business contracts do not contain requirements for the control of measurement devices. Small business contractors are performing measurements of products with devices which must also be of known accuracy.

Recommendations

It is recommended:

1. That MIL-C-45662A be revised and adopted as the standard calibration specification to be referenced in all Government contracts

including small business and R&D contractors where measurements are to be performed.

2. That purchasing officers be required by ASPR or directive to include applicable portions of the revised specification in addition to the special provisions of Standard Form 32.

PROVISION OF METROLOGY SUPPORT TO CONTRACT ADMINISTRATION PERSONNEL

There is a lack of understanding of the need for calibration and metrology among Government and contractor personnel. To overcome this lack of understanding, it is recommended that an orientation film and lecture material be developed for presentation. The Navy and the Air Force both have films which were developed for the particular requirements of their personnel. These films have proved very successful in motivating and indoctrinating personnel in the specific requirements for calibration and metrology in these military departments. These films could be used as guides in the development of a new film for presentation on a wider scale. (AF Film SFP-1047 "USAF Calibration" and USN Film MN-10105 "Why Calibrate").

The calibration and measurement specialists in the cognizant contract administration organizations are trained in the overall evaluation of contractors' programs. However, there is a need for specialized support and training in certain measurement areas such as optics, microwaves, pressure, flow and others. Training courses are available in the military services and from commercial sources in most of the specialized areas. A catalog of available courses should be compiled to provide a ready reference for determining where specific training can be provided. The military metrology engineering centers can also provide specialized training and technical assistance to the cognizant contract administration personnel.

Recommendations

It is recommended:

1. That DoD develop an orientation program for Government and contractor personnel to provide general knowledge of the requirements for a calibration and metrology program in the contractors' plants.

2. That DoD determine specialized training requirements for Government calibration and measurements personnel to improve and augment their capability to evaluate contractors' programs. A catalog of available calibration training courses should be provided. Whenever the specific capability is not available from the cognizant contract administration organization, the technical assistance of the military metrology engineering centers should be requested.

ESTABLISHMENT OF A CENTRAL POINT OF CONTACT WITHIN OFFICE SECRETARY OF DEFENSE RESPONSIBLE FOR OVERALL POLICY FOR METROLOGY AND CALIBRATION AND FOR COORDINATION WITH OTHER GOVERNMENT AGENCIES

For the past eight years, the three departments and AEC have participated in combined meetings to discuss mutual problems concerning metrology engineering and calibration services. These meetings contributed to the important resolution of several problems which interface with NASA, AEC, Department of Commerce, and other Government agencies requiring coordination at the OSD level. However, there is no central point of contast within OSD responsible for overall policy for metrology and calibration, or through which DoD components can present problems involving coordination with other Government agencies. There needs to be a designated office within OSD to provide general policy on metrology and calibration and through which coordination can be attained with Government agencies outside of the DoD. This action will serve the interest of OSD as well as the three departments and DSA.

Recommendation

It is recommended that OSD designate a specific office within OSD (DDR&E, ASD (I&L), possibly the DoD Quality and Reliability Council) for policy direction and to serve as a central point of contact for metrology and calibration matters.

REPORT OF PANEL 9

TITLE: Quality of Technical Data

OBJECTIVE:

To improve the DoD capability to provide data to users that are suitable for the intended purpose, at lowest practical cost.

TOPICS DISCUSSED:

1. Role of the Contractor in Data Quality
2. Government Responsibilities in Data Quality
3. Training
4. Legibility
5. Data Warranty
6. Engineering Data "Defects" and "Rights"
7. Lack of Uniformity in Data Requirements
8. Third Party Evaluation of Data
9. Application of Zero Defects to Data
10. Industry Viewpoints on Data Adequacy
11. Use of Data in Relationship to Quality Techniques
12. Matching Data against Hardware

PARTICIPANTS

Chairman	Col. Ole C. Griffith, USAF, Office, Asst. Secretary of Defense (I&L)
Panelists	Mr. Martin F. Connolly, HQS, AFLC
	Lt. Col. John W. Barlow, USAF, HQS, AFSC
	Mr. D. Capretti, HQS, Naval Material Command
	Mr. D. D. Weintraub, HQS, DCAS
	Col. Samuel T. Jacks, Defense Electronics Supply Center
	Mr. Robert L. Body, Kennedy Space Center
	Mr. I. Appelblatt, Army Mobility Command
	Mr. Norman Miller, Frankford Arsenal
	Mr. F. J. Schiavi, Naval Ordnance Systems Command
	Mr. Cornelius J. Brown Federal Supply Service
	Lt. Col. William C. Shepherd Office, Asst. Secretary of Defense (I&L)
Recorder	Mr. Donald R. Mitchell Office, Asst. Secretary of Defense (I&L)
Monitor	Mr. Irving Altman, Office, Asst. Secretary of Defense (I&L)

ROLE OF THE CONTRACTOR IN DATA QUALITY

Basic quality assurance policy of DoD Instructions 4155.6 and 4155.8 establish the contractors responsibility for assuring that supplies conform to contractual requirements and for performing all inspections and tests called out in the contract. These policies are well suited to data. A key to better data quality lies in further amplifying and enforcing contractor quality assurance practices. Adequate drawing quality and content and assuring that data accurately reflects hardware produced is a responsibility of the contractor.

Although MIL-Q-9858 requires that contractors establish a quality program, it contains very little criteria on what the minimum constituent elements or a data control program must be. Consequently, the government has little basis for criticizing or disapproving a contractors data quality program, and offers minimum guidance to a government inspector or other government personnel who review such a program.

Recommendation

It is recommended that DoD develop and specify the minimum elements of an acceptable contractors data quality program in all contracts requiring data delivery. These requirements should be placed in a military specification, preferably in MIL-Q-9858, (Appendix A provides recommendations for the minimum elements to be included in a contractors data quality program).

GOVERNMENT RESPONSIBILITIES IN DATA QUALITY

The DoD has several basic responsibilities that affect directly the utility of the data product for its purpose:

1. Formulating data requirements that meet but do not exceed the requirements of users.

2. Communicating these requirements to the contractor clearly and concisely, and ensuring that he understands them.

3. Developing system requirements for data quality control.

4. Developing procedures for audit/review of contractors QA Program for technical data control.

5. Accepting of final data product based on contract requirements.

6. Assuring the proper use of data acquired.

The force of DoD's technical data program is directed toward the formulation of data requirements and communicating them to the contractor. Therefore, this panel did not consider these aspects of the problem in detail. This panel feels that the area in need of most improvement lies in assuring that the contractors clearly understand the data requirement, and that the execution of his data quality program is effectively monitored by specialists in the fields that are affected by the data product. These specialists might include engineering, procurement, maintenance, drafting, production, materials, standardization, quality assurance, and other types of personnel.

Present directives dealing with provisioning must insure recording of procurement method, to justify the method recorded, and provide timely intra-government exchange of current technical data to the purchasing agency to insure timely customer support.

Recommendations

It is recommended:

1. That DoD Instruction 5010. 12 be modified to include a detailed statement of Government responsibilities relative to acquisition of technical data, i. e. review, evaluation of contractors quality program for control of Technical Data.

2. That DoD develop a handbook similar to MIL Handbooks 50, 51 and 52, outlining procedures for review of the adequacy of contractors technical data control systems.

3. That DoD revise appropriate provisioning regulations to require that supply support requests record the method of purchase, provide necessary justification, and include technical data suitable for the method of purchase specified. Page 3-14, Attachment II, Encl. 3, of Joint Regulation issued under No's DSAR 4140.35, AR 710-25, AFR 67-8, BUSANDAINST 4423.10, MCO 4423.9 requires revision to implement this recommendation.

TRAINING

Competency in determining quality aspects of technical data to contractual requirements is dependent upon qualified and experienced government personnel. Experience has demonstrated that many personnel concerned with quality assurance acceptance functions are in need of specialized training in data management techniques and specifications requirements to assure that contractor's program results in preparation of data to contractual requirements.

Recommendation

It is recommended that a training syllabus be developed that will cover the essentials required for government personnel concerned with data quality assurance. An appropriate training syllabus might include the following subjects:

1. Coverage of material essential to the functions of the QA technical data specialist.

2. Factual information for formulating decisions and interpretations of specification/standard requirements.

3. Coverage of technical data vocabulary and meanings.

4. Importance of procuring technically accurate and adequate data.

5. Inspection/acceptance of data.

6. Inspection techniques.

LEGIBILITY

Technical data acquired by the DoD are often illegible and are not capable of producing legible microfilm or copies for support of intended functions.

The principal specifications and related documents developed to ensure legible technical data, MIL-D-1000 for Engineering Drawings and Associated Lists, MIL-M-9868 for microfilm, MIL-D-5480 for drawing reproduction, and MIL-HDBK-303 which gives guidance for microfilming are sound. The proper use and consciousness of these specifications, to a great degree, have reduced the problem of illegibility, particularly during the phase of preparation of original technical data.

However, data, not prepared or reproduced under such finite controls continue to be an important problem. Many engineering drawings prepared before microfilming became generally practiced are not suitable for microfilming or reproduction. A major part of the problem rests with the preparation of microfilm aperture cards and other type reproduction from illegible originals and first generation microfilm therefrom and the subsequent use of these aperture cards in procurement bid sets.

Recommendations

It is recommended:

1. That existing technical data (engineering drawings) which are illegible and necessary to support DoD assigned functions be considered for restoration through the use of phototracing and photorestoration processes. The preparation of new drawings or redraws should be accomplished as a last resort.

2. That in the preparation of new technical data, the Services continue emphasis on inspection by contractor and verification by government skilled, and technically trained personnel for legibility and reproducibility in accordance with specified and mutually understood governing specifications. These actions should take place during all phases of preparation and subsequent processing and handling of technical data.

DATA WARRANTY

The "data withholding of payment" clauses of ASPR 9-207.2 provide for withholding of monies for failure on the part of the contractor to make timely deliveries of data or because the data offered for acceptance is deficient. If deficient data are accepted by the Government, such acceptance legally relieves the contractor of his contractual obligation to complete or correct the data. Inaccurate and incomplete data may prevent the Government from utilizing the data for the purpose for which it was procured, including competitive reprocurement.

The scope, complexity and sheer volume of scientific and technical data causes a thorough review by qualified Government personnel of delivered data, before acceptance, to be administratively impractical. On the other hand, the contractor is not only contractually bound, but also is uniquely qualified by reason of intimate knowledge of his own methods of manufacture, processes, and know-how to undertake the burden of assuring compliance with his contract data requirements. Based upon this premise, an Air Force - Industry team considering this question has prepared a warranty clause for inclusion in DoD contracts. This clause guarantees to the Government that the data the contractor delivers is complete and accurate in accordance with his contractual data requirements. The clause also requires the contractor to supply, correct, or replace the deficient data provided he is notified of the deficiency within a specified period of time after the data is delivered.

Recommendation

It is recommended that the ASPR Committee favorably consider the data warranty clause jointly developed by Air Force and Industry.

ENGINEERING DATA "DEFECTS" AND "RIGHTS"

The major deficiencies in the compliance, by contractors and vendors, with drafting standards, accounting for approximately 75% of the data rejected by one military service are as follows: (1) incorrect drawing/part number representation; (2) material processes not identified; (3) contractors and vendors documents referenced on drawings not submitted; (4) dimensions/tolerances omitted; (5) improper use of proprietary legends. Any combination of the above deficiencies has been called "swiss-cheese" drawings. There is evidence that a substantial portion of these deficiencies are attributable to the effort of contractors to prevent "so called" proprietary information from being disclosed to potential competitors.

All five deficiencies have a major impact on logistics operations. The primary impact of "rights" is relative to the procurement process and applicable only to a relatively small number of items or drawings. To a large extent this process is complicated by the necessity on the part of the "prime" contractors to flow-down data rights provisions to vendors.

The base of "intended usage" provided in Mil-D-1000 coupled with ASPR Data Rights revision, provide an improved frame of reference with respect to data quality. ASPR revisions now permit the government to recognize a "limited use" for privately developed data. When the data requirements are for a reprocurement mission ASPR revision permits specific negotiation for the purchase of privately developed data for competitive procurement purposes.

Recommendation

It is recommended that current contracts be reviewed by the Services, and when economically practical, the current ASPR provisions be applied to appropriate data requirements.

LACK OF UNIFORMITY IN DATA REQUIREMENTS

The need for completeness and elaboration of technical data increases directly with expansion of the distance between the designer and the production shop. The proportionality also exists with respect to the number of contractual and administrative barriers between the man on the drafting board and the man on the man on the drafting board and the man on the machine.

A small shop in which the designer is personally able to convey instructions to the machinist, etc., by word of mouth needs much less in the way of technical data than does a large integrated industry with many suppliers and automated machinery. These needs, which directly reflect their ability to control the design and quality of product, determine elaboration of data. This has resulted in the proliferation of parochial drafting standards and untold variations from standards.

Current government contracting practices are such that government agencies' needs for completely defined drawing information in many instances exceeds that of industry. In addition, in spite of extensive standardization efforts, the different military services impose differing requirements for essentially the same needs, which vary in accordance with the parochial differences of their major supplier industries.

Latitude must be provided for each service to meet needs peculiar to it. However, it is felt that an optimum degree of standardization has not been attained. Greater uniformity of practices would greatly reduce data quality problems, especially as they pertain to vendors. The advantages of the contractor and the government communicating in identical, completely understandable technical language, which is after all, all that a drawing package is supposed to do, are many. If we had such identical practices initially we would not have to pay a premium for drawings initially made or redrawn to our requirements.

We would also save considerable time, avoid expensive misunderstandings, and better utilize scarce engineering resources.

The benefits of such a program are significant enough to be translated to a national scale for the eventual improvement of our nation's technology.

Panel 9 recognizes that the DoD has for a number of years directed programs to bring about greater uniformity in drafting practices. The panel endorses these efforts but believe they should be accelerated.

Recommendations

It is recommended:

1. That the DoD, under the monitorship of the Office of Technical Data and Standardization continue, and accelerate to the extent possible, programs to bring about greater uniformity in the drawing practices of the military services.

2. That DoD accelerate its efforts and provide leadership to develop and promote national standardization of drawing practices for the purpose of eventually adopting a national system of drawing practices. Consideration should be given to use to the Federal Series of documents.

THIRD PARTY EVALUATION OF DATA

It has been suggested often that the DoD might overcome the problem of data quality by employing a "third party" contractor to evaluate the data produced by prime contractors before acceptance by the government.

Based on review of experience and informed opinion with regard to use of "third party" contractors, Panel 9 feels that the value of such use is limited. To obtain proper results, a data review activity must have direct experience and current knowledge associated with the development itself.

There is always some gain in accuracy and completeness resulting from any comprehensive review. To the extent that DoD activities might be limited in their capacity to perform a comprehensive review, "third party" contractors can be employed advantageously.

Recommendation

It is recommended that "third party" contractors be employed only after careful consideration on a case by case basis where limited in-house capability prevents adequate review of data. Such contractors should not be employed for evaluation of technical content of data except under unusual circumstances.

APPLICATION OF ZERO-DEFECTS TO DATA

The concept of Zero Defects (ZD) has not been fully exploited in the technical data area. In cases where ZD has been applied to data, beneficial results are at least as great as those achieved with hardware. An article in the Wall Street Journal on 6 April 1965 quoted dramatic reduction of drawing errors by the General Electric Company after application of the ZD concepts.

Panel 9 feels that no attempt should be made to initiate a separate ZD program for data, but that more can be done to insure that ZD concepts are applied to data wherever ZD is used.

Recommendation

It is recommended that the Services introduce technical data considerations in all ZD activities.

INDUSTRY VIEWPOINTS ON DATA ADEQUACY

The Office of Technical Data and Standardization Policy is fully committed to the practice of working closely with Industry on all policy matters within its purview. DoD's files are replete with Industry association reports and studies on many aspects of data acquisition, preparation, handling and retrieval. Many of these reports have led to major improvements in DoD policies and practices. However, some industry recommendations are so general as to be of little use, some deal with detailed drafting techniques, but none deals specifically and broadly with data quality.

Recently a selected group of knowledgeable and respected individuals in a variety of industries was queried on this particular subject. The replies, made frankly and in the spirit of helpfulness, represent a cross-section of American Industry. There is some disagreement among them and certainly many of their remarks would be challenged by various elements of DoD. Nevertheless, they are the well-thought-out viewpoints and observations of responsible managers and operating officials who live daily with the problems of creating technical data and complying with our voluminous and often inconsistent requirements.

In the interest of providing a balanced documentation of the subject of data quality, the letter which requested the comments and a sampling of the replies have been included in Appendix B. Since these were personal replies to a personal letter, identification of individuals and their affiliation have been deleted. The authors' permission to reproduce their letters is gratefully acknowledged.

Recommendation

It is recommended that the thoughts expressed in these and the other letters received be objectively considered by those in the DoD components who are responsible for data policy and requirements.

USE OF DATA IN RELATIONSHIP TO QUALITY TECHNIQUES

Quality of engineering data involves considerations from configuration management thru the cycle of mission usage to disposal. Sampling of the compliance with drafting standards indicates that approximately 7% is defective. These defectives have a serious effect on logistics operations. Of the millions of drawings received each year it is estimated that the probability of use for reprocurement lies within 5%. Generally, this use is the most demanding one for comprehensive detail.

The DoD policy of "mission orientation" is outlined in MIL-D-1000 and further defined in the "ordering" techniques of the services. Related programs such as MIL-STD-789 (ASG), "Procurement Method Coding of Aeronautical Replenishment Spare Parts" provides for item by item determination and the acquisition of data appropriate to the method of procurement intended.

This identification or selection of spares and repair parts for competitive procurement during the acquisition cycle provides a listing of items that could be used to provide for the application of special Quality Assurance techniques for such items.

Recommendation

It is recommended that the current project to expand such techniques as provided by MIL-STD-789 (ASG) to a DoD wide document be expedited. Quality assurance techniques should provide special consideration for items designated for competitive procurement.

MATCHING DATA AGAINST HARDWARE

Data is a basic management tool which provides the vital link essential to maintenance of a closed loop effort between the conceptual definition, acquisition and operational phase of any significant weapons system program. There is a logical progression by which the pervasive influence of data extends to embrace configuration management. When data for competitive procurement is applied and used in an orderly fashion, following a defined series of procedural steps and decision rules to end in a design decision, a configuration has been established. The First Article Configuration Review (FACI) or configuration audit review (CAR) is a technical audit comparing prototype hardware with the technical data, drawings and specifications, to be used in describing the production baseline. When prototype hardware has been produced the technical data of this unit shall be compared directly with the as-built configuration of the same unit. The as-built unit will be compared directly with the engineering drawings to the level of design disclosure specified on the drawings and related data assembled by the top drawing specified in the description. The DD Form 250 (Material Inspection and Receiving Report) will not be completed until differences in documentation and as-built configuration are corrected.

The best way to improve the quality of a technical data package for competitive procurement package is to use it in the manufacture of a limited production quantity before undertaking full-scale production. This limited production experience will shake out the numerous errors and omissions introduced during development of the technical data package. Subsequent field testing or service evaluation of this limited quantity will reveal additional weaknesses not detected during earlier prototype tests, or those that are propagated by unfamiliar personnel usage or fleet/field abuse. The feedback from fleet/field use when included with the limited production experience will provide a package suitable for full-scale production. Although the limited production will not eliminate all of the changes that will be found necessary during the first full-scale production run, it will substantially improve the condition. With subsequent procurements, the number of necessary changes will continue to decline as the quality of the technical data package continues to improve with maturity. Unfortunately, the best technical data package for production is the one no longer needed at the end of the production period.

The validity of technical data varies from that which has been proven by having single units produced to that resulting from corrections identified by limited production quantity field/fleet use.

Recommendations

It is recommended:

1. That validation of drawings be accomplished by building testing and obtaining feedback from the maximum number of items practical.

2. That the Services include requirements in the contractors' data control programs for configuration audit review to insure that data delivered matches the hardware.

Appendix A

ELEMENTS OF A CONTRACTORS DATA QUALITY PROGRAM

The DoD document recommended should establish at least the following requirements for a quality program to provide technical data to the requirements of the contract:

1. Contractor shall maintain an effective and economical quality program for technical data, which is planned in consonance with other administrative and technical programs. The program including procedures, shall encompass all aspects of technical data quality during all phases of preparation (planning, outlining, drafting, change control, writing, reviewing, validation, etc.). The extent of the program established shall be based on the complexity of the hardware covered and the interchangeability and reliability requirements thereof. The program shall assure that adequate use of technical data is maintained throughout all areas of affected contract performance and shall provide for the prevention and ready detection of discrepancies and for timely positive corrective action. The contractor shall maintain and make available to the government representative objective evidence of technical data conformance to contractual requirements.

2. Procedures required shall include, but not be limited to, those providing for the inspection and approval of technical data for scope, style, format, legibility, reproducibility, technical accuracy and adequacy, and the presence of required instructions and information. The procedures shall provide the method, place and organization responsible for the performance of technical data inspections, reviews and validation exercises.

3. The contractor shall establish and maintain control at located points in the preparation and production of technical data to assure continuous control (in-process inspection) of accuracy and adequacy of data and their total conformance to contractual requirements. The controls instituted shall be suited for the type of procurement defined by the contract or order.

4. Measuring and testing devises used in validating and verifying technical data shall be calibrated against measurement standards on designated measuring equipment traceable to the NBS, at established periods to assure continued accuracy. The contractor shall prepare and maintain a written schedule for the maintenance and calibration of such equipment based on type, purpose and degree of usage.

5. Drawing and change control features of paragraph 4 of MIL-Q-9858A should be made applicable to change control of all pertinent data required by contracts.

6. The quality control program shall delineate procedures and their controls that will produce adequate technical data for delivery within contractual schedules.

7. The quality program, including procedures, shall be documented and subject to the review by the local government representative. The procedures shall, including listings of contractor organization, be responsible for check and control points through the phases of technical data development, validation, verification and production.

8. Records of all inspections, reviews, validations, verifications and corrective actions performed by the contractor shall be kept complete and available to the government during the performance of the contract.

Appendix B

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
Washington, D. C. 20301

INSTALLATIONS AND LOGISTICS 9 May 1966

Determining the adequacy of data is one of the fundamental concerns of this Office. To date, we have moved fairly slowly in this area due to the pressure of other problems. We now feel, however, that the time has come to identify more thoroughly the nature of this problem and to consider what actions need to be taken.

To this end, I have established a military group to study and to recommend actions to improve data quality, starting with drawings. In addition, a project has been initiated to strengthen the quality assurance privisions of MIL-D-1000. Both of these efforts are just getting under way.

Experience to date indicates that there are many instances where the quality of drawings delivered to the government is not up to specifications. We do not know as yet how general this condition is, but we do know that in cases where sampling inspection has been used as the basis for acceptance, the quality of drawings has risen sharply. Therefore, we have been seriously considering requiring the use of sampling techniques for acceptance of drawings delivered under MIL-D-1000. We have received comments, however, which indicate that sampling procedures should not be made applicable to drawings.

Generally, we believe a quality of drawings analysis can be broken into two main divisions: (1) technical and (2) format. The former pertains to the degree to which the drawing reflects the product produced, and the latter pertains to the relationship of the drawing to "design disclosure" and format requirements of MIL-D-1000 and MIL-STD-100. There appears to be a tendency to place format adequacy in a role of secondary importance to technical adequacy. With respect to mundane requirements such as the size of title block, this a valid observation. But, to the extent that drawings omit needed information or express information in terms of company practices, drawings may well not be usable by the government if format requirements are not met.

In view of the above, I would appreciate your comments on the major aspects of this problem and specifically with respect to:

1. Whether or not, to your knowledge, the DoD has a general quality problem in connection with drawings it acquires.

2. What actions would you recommend to improve the quality of drawings?

3. To what extent, if any, quality assurance or inspection personnel should become involved in checking drawing quality?

4. Should sampling techniques be used?

5. Can we rely on in-process controls on drawing quality to the exclusion of a thorough final inspection?

To my mind, the assurance of data quality ranks equally with the cardinal problems of data requirements, rights in data, and the storage/retrieval problems. I shall, therefore, be looking forward to your thoughts on this subject.

Sincerely,

(Signed) O. C. Griffith
Colonel, USAF
Acting Director, Office of Technical
Data and Standardization Policy

June 20, 1966

Colonel O. C. Griffith
Acting Director, Technical Data and
Standardization Policy, Office of the
Assistant Secretary of Defense (I& L)
Cameron Station, Building 3
Alexandria, Virginia

Subject: Adequacy of Data

Dear Ole:

In the past, I have discussed with you my viewpoints on a sampling procedure to review the quality of data to be submitted to the customer. I have forwarded to you copies of our procedure and charts showing progress in improving output within our department. We have found this procedure to be very beneficial for many reasons. Naturally, from the experience of the past three years, I am in favor of a controlled quality assurance audit or sampling inspection prior to submission to the DoD.

Specifically as to your questions:

1. From my past experience, serving on committees to the various services in DoD, I have come across many circumstances where DoD had a quality problem. From these circumstances and our own experience, I believe that they have a general quality problem. I think this problem places a conscientious contractor in an unfavorable position on competitive bids. To assure quality documentation, a system of control, which does affect costs, is required.

2. I recommended that the services review, on a sampling basis, and not necessarily in accordance with MIL-STD-105, the output of a company to assure that within reason the documentation meets the requirements. Naturally, from our own experience, I believe that our quality assurance program could be adapted by the military and assure quality documentation.

3. I do not believe that quality assurance or inspection personnel, as we think of quality control personnel, should become involved in checking drawing quality. Within our department, we check practically 100 percent of our output by what we call "career checkers", which is our highest drafting classification. However, as mentioned before, we do have a quality audit program, in which we have two to four

professional auditors review, on a sampling basis, the data package from the 1423 input through the microfilm output.

4. Yes, in accordance with the enclosed report.

5. No, I do not believe so. I believe, no matter how conscientious and competent a company is, there has to be some quality assurance audit by the customer. This will vary depending upon the past performance, but should not be excluded.

June 17, 1966
C1-75-50/FS

Col. O. C. Griffith
Acting Director
Office of Technical Data and
Standardization Policy
Department of Defense
Building 3 - Room B110
Cameron Station
Alexandria, Virginia 20301

Dear Ole:

About 1954-55 the first attempt was made to include data, as such, under the quality control Specification MIL-Q-5923. Since then there has been great amount of argument and difficulty over what appeared to us to be a relatively simple matter. This is not to say that there were no problems associated with data quality. Primarily, such problems concerned the legibility of the reproduction furnished, although some other problems concerning the completeness of data and the proprietary rights thereto were also involved. Approximately 95% of these other problems occurred (and still do occur) in the area of vendor data. We estimate vendor data to comprise at least 50% of the overall data package, and a far greater percentage of the total data problem.

Data displays design and manufacturing information and instructions, and the adequacy of those instructions cannot be demonstrated as a function of quality control of data. The adequacy of design and manufacturing instructions is subject to review and checking within the contractor's engineering effort and is demonstrated by the eventual production of hardware and its appropriate use. For any customer agency to do an adequate job of "quality control" with respect to the adequacy of the information shown on the drawings would require duplicating the contractor's engineering effort, including a review of all facets and tradeoffs concerned with safety, reliability, maintainability, standardization, produceability, performance, logistics support, etc.

As a matter of fact, these other engineering disciplines are being policed as such by the specific design and review organizations which are required by the various specifications concerning them; i. e., specifically--safety, reliability, maintainability, standardization, etc. Beyond this the compliance of design information shown on data to the hardware involved is subject to demonstration at Contract Technical

Compliance Inspections (CTCI) or First Article Configuration Inspections (FACI), and the maintenance of the currency of such data is policed by disciplines such as "Configuration Management."

A further point along this line is the fact that a contractor is subject to the same limitations when considering vendor or sub-contractor data. The prime reason for going to a vendor/sub-contractor for design and/or hardware is the fact that the appropriate design technology/capability does not exist in-house. If the prime contractor had the capability--in technology and manpower--to thoroughly authenticate the design completeness of the vendor/subcontractor data, the prime would probably do the work himself initially, rather than simply duplicate the work done by the vendor.

It would seem then, that the only really legitimate "quality control" functions affecting data of itself, are the so-called "--mundane requirements such as the size of the title block, --" and/or the legibility of reproductions of that data as supplied upon call. No contractor should ever object to a customer's review for legibility. We may challenge his eyesight on occasion, but certainly we can be expected to furnish data which is readable. Further, we can be expected to furnish data which complies with the mechanical aspects of data requirements, such as drawing size, drawing format, etc. Beyond this there is no logical or reasonable basis for quality control of a data package.

We might suggest that a major portion of the legibility problem of data is generated by the practice of the governmental agencies in obtaining all the data, reproducing it for distribution to prime agencies, and in turn reproducing again (sometimes twice) before delivery to the eventual user. This third, fourth, or fifth generation copy could only be made good if it started from the ultimate in drawing originals--an ink tracing. This is obviously a very expensive way to get readable copy to the end user. A better way (now being implemented through "contractor data bank--'call' contract" procedures) is to let the contractor supply direct to the user.

With respect to the specific five questions that your letter proposes, my answers are as follows:

1. I have no doubt that the DoD has some quality problems in connection with the drawings it acquires. I do not believe that the correction of these problems, other than as they apply to format or legibility, is susceptible to additional quality control requirements or procedures.

2. Our recommendation with respect to improving the quality of drawings would be to return to the status of quality requirements that obtained with MIL-D-5481 or MIL-D-5028. I firmly believe that other facets of customer control of the contractor's activities, such as configuration management, safety, reliability, maintainability, standardization, etc., more than adequately account for and cover various facets of design completeness and accuracy as proper tradeoffs on engineering data.

3. It is our position that quality assurance or inspection personnel should not become involved in checking drawing quality, other than possibly for legibility and/or format.

4. Sampling techniques restricted to the checking of legibility and/or format would be acceptable.

5. It is our position that the only reasonable quality controls that can be imposed on the adequacy of design information contained on engineering data is the in-process control maintained by a contractor in the form of a checking group within the engineering release system.

Best personal regards.

Very truly yours,

AVS:lc

cc: Advisory Committee to OTDSP

20 June 1966

Colonel O. C. Griffith, USAF
Acting Director, Office of Technical
Data & Standardization Policy
Office of the Assistant Secretary of Defense
Room 3D232 - Cameron Station
Alexandria, Virginia 22314

Dear Ole:

With regard to your letter of 9 May 1966, the matter of the quality of drawings has been carefully considered by our Engineering Drawing personnel. Their opinions on this problem are set forth in this letter.

It is agreed that an analysis of the quality of drawings can be broken into two main divisions. It has been our practice to refer to these divisions as the technical and non-technical quality aspects of drawings.

The quality of a drawing (or a set of drawings) with respect to the technical aspects must take into consideration the design phase in which the drawing is prepared and utilized. As the design details become more firm and the life of the drawing extends into subsequent design phases the drawing approaches a stage where it contains a complete and adequate set of engineering requirements which delineates the design for fabrication, assembly, inspection, test and utilization of the item described. Prior to this stage the degree of completeness of the engineering requirements on the drawing is commensurate with factors such as availability of firm design information and existence of in-plant channels of communication by which requirements are made known or understood.

Evaluation of the non-technical aspects of a drawing (or set of drawings) takes into consideration general drafting practices for recording design information after it has been established and consideration of the suitability of the drawing for its intended use. The general drafting practices referred to pertains to drawing characteristics such as the following:

a) drawing sheet format
b) lines, lettering and symbols
c) types of drawings
d) drawing package makeup for an item
e) legibility and reproducibility

With respect to your specific questions our comments are as follows.

Question No. 1: We have no knowledge as to whether or not DoD has a general quality problem in connection with the drawings it acquires. To our knowledge, drawings submitted by . . . have been satisfactory. In general, based on our association with other Aerospace Industries, it is doubted that major drawing quality problems emanate from the larger Aerospace companies. It is pointed out that a quality problem may exist when drawings are ordered prematurely since such drawings will not be complete and may not contain firm engineering requirements. The . . . requires that engineering drawings for all production items be similar in nature and content as drawings required by DoD primarily because of decentralized design and drafting and extensive internal use by one or more major functional activities such as Manufacturing, Quality and Support. For such an organization, uniform drafting practices are required and the drawings must be complete to the maximum practical extent.

Cost effectiveness also comes into the picture of drawing quality since there is a limit to the amount and detail of technical information which may be recorded on a drawing and to the degree of emphasis to be placed on details and strict adherence to non-technical quality aspects. It is our belief that it is not necessarily economically practical to expect that drawings be prepared to support manufacture by another company even though that company is a competent manufacturer in the same or allied industry.

Question No. 2: It is recommended that analysis and action be directed to the known cases of grossly inadequate engineering data submittals rather than taking across the board actions. The quality assurance provisions of MIL-D-1000 are considered generally adequate.

Question No. 3: The technique for assuring drawing quality logically differ for the technical and non-technical quality aspects in our opinion. Quality assurance for the technical aspects is primarily performed by the engineering checking function. Further assurance is obtained through 1) the drawing release and change control systems and 2) the contractor's hardware quality assurance system. For the non-technical aspects, quality assurance is best performed by the engineering checking function and drawing control personnel in the engineering organization who are specifically assigned this responsibility. The drawing control function provides assurance of conformance to selected non-technical characteristics and to overall requirements which pertain to a total package of drawings.

Question No. 4: Sampling techniques would be suitable as a partial measure of conformance to the non-technical quality aspects. In our opinion, sampling techniques are unsuitable for inspection of technical quality aspects. Sampling techniques at final data inspection for non-technical aspects have been used successfully by ... for some time. When used, sampling has proven to be an economical technique for assuring quality over and above that provided by the in-process engineering checking and data control functions. Because each company needs to establish its sampling plans to fit its mode of operation, standard sampling plans for universal use are probably not feasible.

Question No. 5: In-process controls must be relied on to assure drawing quality with respect to the technical quality aspects. These controls are inherent in operations such as configuration review, engineering checking, drawing release, hardware quality assurance and configuration control. A thorough and final inspection would be impracticable and costly. For the non-technical quality aspects, in-process controls alone may not be completely adequate. In our opinion, a final inspection is needed to determine that:

a) The engineering data as a package is suitable for the intended use for which it is being submitted.

b) The set is complete.

c) Assurance that the non-technical contractual requirements for Form 1, 2 or 3 as specified in MIL-D-1000 are met, and

d) Legibility and reproducibility is adequate.

In conclusion, we strongly support the Aerospace Industries Association efforts in establishing a basic understanding of the engineering drawing as presented in the AIA presentation "The Engineering Drawing - Its Purpose and Application". It is believed that the interchange of viewpoints and information between AIA and DoD will provide a mutual understanding on the subject of drawings and an opportunity to recognize areas of potential drawing quality problems.

We appreciate this opportunity to emphasize the importance of drawing quality and to provide our comments on this subject. We trust that the above comments will aid your efforts in determining the adequacy of data.

Best regards.

Sincerely,

cc: Advisory Committee to ORDSP

June 16, 1966

Col. O. C. Griffith, Acting Director
Office of Technical Data and Standardization Policy
Office of the Assistant Secretary of Defense (I&L)
The Pentagon
Washington, D. C. 20301

Dear Ole:

With respect to your letter to me posing questions with respect to the assurance of the quality of drawings furnished to government agencies by contractors, I have the following comments which were developed from comments by cognizant personnel in . . . .

1. We agree that DoD has a general quality problem in connection with the drawings it acquires. This opinion is based on the microfilm of other companies' data which we have received from the government to manufacture equipment. However, I am sure that if you ask each company to comment on its quality, you will be assured that that company submits drawings of the highest quality to the government. My personal opinion is that somewhere in between lies the truth.

2. It is our belief that the requirements in the specification governing drawing content, format and legibility are entirely adequate. It is the enforcement of these requirements that is not consistent. In addition, there does exist the problem of the differentiation between "technical" content and "format" and it is our experience that "format" rather than "technical" content has taken primary importance. Therefore, in order to differentiate it is recommended that "format" and "technical" will have to be more definitively defined.

3. Most companies have drawing checkers who check drawings for "format" and "technical" adequacy. However, quality assurance or inspection personnel (as distinct from drawing checkers) are usually qualified to inspect drawings for format conformance only because they are not normally equipped to pass on the technical adequacy of drawings, therefore checking outside the drafting room should be limited to format requirements.

A closer liaison between the inspector and contractor personnel early in the contract would help eliminate many of the problems discovered at the end of the contract. Differences of opinion in many instances, and they are just that, could be resolved early in the contract and uniform ground rules would thereby be established sufficiently in advance to resolve many of the problems which are minor.

4. Sampling techniques will not assure drawing adequacy. Legibility of a print will provide assurance that another print made from the same drawing will be legible, depending of course on the number of times used. The fact that the drawing is correct, however, will not provide assurance that another drawing is also correct. Both drawings being dissimilar items must be inspected for all attributes. I must admit that this opinion is a consensus and that there is not unanimous agreement in . . . on this point.

5. In process controls can be relied as to assure conformance of drawings to all requirements except legibility. Legibility degrades with drawing use, all other attributes do not change. In this connection we would like to comment that the state of the microfilm art is not yet adequate to produce the consistency legible fourth generation microfilm required by MIL-M-9868.

Another point worth mentioning is the fact that each military activity has its own opinion, or sometimes no opinion at all, as to what constitutes a satisfactory data check either in content, format or acceptability. There should be an educational program instituted which would create a greater dependability as to the requirements of a satisfactory data package.

There still remains the problem of adequately defining drawing requirements and the kinds of drawings, e. g., the continuing dispute over MIL-D-1000. If you have difficulty in defining the requirement, how do you know what you are to inspect.

Very truly yours.